UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF PREVENTION,
PESTICIDES AND
TOXIC SUBSTANCES

January 2, 2001

MEMORANDUM

SUBJECT: SECOND REVISION OF "OCCUPATIONAL AND RESIDENTIAL EXPOSURE ASSESSMENT AND RECOMMENDATIONS FOR THE REREGISTRATION ELIGIBILITY DECISION DOCUMENT FOR ENDOSULFAN"

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Please find the review of Endosulfan.

DB Barcode: D269412

Pesticide Chemical Codes: 079401

EPA Reg Numbers: 16-141, 70-142, 264-637, 264-638, 264-656, 264-658, 264-659, 279-1380, 279-2306, 279-2659, 279-2924, 279-3129, 279-3222, 802-516, 1386-338, 3342-102, 5481-278, 5481-296, 5905-418, 9779-330, 10163-98, 10163-110, 10163-130, 10163-223, 11678-5, 11678-25, 19713-99, 19713-319, 19713-399, 34704-21, 34704-516, 34704-799, 51036-91, 51036-92, 51036-209, and 66222-2.

	Individual State Registrations
	AZ-93001200, AZ-93001300, AZ-93001400, AZ-98000400, AZ-98000500, CA-76011500, CA-86003500, CA-90003100, HI-88000800, HI98000200, ID-87001300, ID-89000900, ID-97000600, ID-97000900, ID-98000200, ID-98000300, ID-98001100, ID-98001200, MS-81003500, MS-81003600, MT-87000200, MT-87000300, NC-00000400, NV-86000500, NV-93000400, OR-77004200, OR-77004300, OR-78002000, OR-96000400, OR-98000800, OR-99005100, WA-00002300, WA-77001600, WA-78002900, WA-78003300, WA-87001200, WA-87001300, WA-90002300, WA-98001200, WA-98001500, WA-98001600, WI-98001700, WA-98002700, WA-98002800, WA-99002500, WA-99003200, WI-99000100, and WA-97000200.
EPA MRID Numbers.:	403039-01, 410485-01, 410485-02, 417152-01, 444031-02, 449391-01, and 452172-02
PHED:	Yes, Version 1.1

OCCUPATIONAL AND RESIDENTIAL EXPOSURE AND RISK ASSESSMENT

EXPOSURE AND RISK ASSESSMENT/CHARACTERIZATION

Purpose

In this document, which is for use in EPA's development of the Endosulfan Review Reregistration Eligibility Decision Document (RED), EPA presents the results of its third review of the potential human health effects of occupational exposure to endosulfan.

Criteria for Conducting Exposure Assessments

An occupational and/or residential exposure assessment is required for an active ingredient if (1) certain toxicological criteria are triggered and (2) there is potential exposure to handlers (mixers, loaders, applicators, etc.) during use or to persons entering treated sites after application is complete. For endosulfan, both criteria are met.

Summary of Toxicity Concerns Relating to Occupational and Residential Exposures

Acute Toxicology Categories

Table 1 below presents the acute toxicity categories as outlined in the Report of the Hazard Identification Assessment Review Committee (October 7, 1998).[1]

Table 1: Acute Toxicity Categories for Endosulfan Technical

Guidelines	Test	MRID	Results	Toxicity Category
81-1	Acute Oral Toxicity	00038307	LD_{50} =40.38 mg/kg in ♂ LD_{50} =9.58 mg/kg in♀	I
81-2	Acute Dermal Toxicity	41183503	LD_{50} = 2000 mg/kg	III
81-3	Acute Inhalation Toxicity	41183504	LC_{50} = 0.16- 0.5 mg/L	II
81-4	Primary Eye Irritation	255157	Eye irritant (Residual opacity at day 13)	I
81-5	Primary Dermal Irritation	00038309 00128649	Non-Irritant Slightly Irritant	IV IV
81-6	Dermal Sensitization	00136994	Not a dermal sensitizer	

Other Endpoints of Concern

The Report of the Hazard Identification Assessment Review Committee (January, 2000)[2] indicates that there are toxicological endpoints of concern for endosulfan. The endpoints used in assessing the risks for endosulfan are presented in the Table 2.

Table 2: Endpoints for Assessing Occupational and Residential Risks for Endosulfan[1]

Route / Duration	NOAEL (mg/ kg/day)	Effect	Study	Uncertainty Factors and Safety Factors
Short term Dermal (1 to 30 days)	3.0	Hepatotoxicity (enlargement of parenchymal cells, loss of cytoplasmic basophilia and isolated cell necrosis and frequent mitosis) in both sexes at 9 mg/kg	21-day dermal toxicity study in rats	Interspecies: 10x Intraspecies: 10x FQPA: 3x
Intermediate-term Dermal (one month to several months) and Long-term Dermal (several months to a year)	3.0	Hepatotoxicity (enlargement of parenchymal cells, loss of cytoplasmic basophilia and isolated cell necrosis and frequent mitosis) in both sexes at 9 mg/kg	21-day dermal toxicity study in rats	Interspecies: 10x Intraspecies: 10x FQPA: 3x Use of 21 day study for exposure duration greater than 30 days: 3x
Short term Inhalation (1 to 30 days)	0.2	Decreased body-weight gain and decreased leukocyte counts in males and increased creatinine values in females at 0.002 mg/L (0.40 mg/kg/d)	21-day inhalation study in rats.	Interspecies: 10x Intraspecies: 10x FQPA: 3x
Intermediate-term Inhalation (one month to several months) and Long-term Inhalation (several months to a year)	0.2	Decreased body-weight gain and decreased leukocyte counts in males and increased creatinine values in females at 0.002 mg/L (0.40 mg/kg/d)	21-day inhalation study in rats.	Interspecies: 10x Intraspecies: 10x FQPA: 3x Use of 21 day study for long term exposure duration: 3x

FQPA Safety Factor

The FQPA Safety Factor Committee memo dated November 20, 1998[3] concluded that the **FQPA safety factor** is required, however can be **reduced to 3x** because: 1) there is no evidence of increased susceptibility in any study; 2) the severity of the fetal effects in the reproduction study

were not consistent between generations and the target organ toxicity seen in this study was not seen in any other study; and 3) reliable data and conservative assumptions in screening level models were used to assess the potential dietary (food and water) and residential exposure to this chemical. Consequently the FQPA safety factor was reduced based on the uncertainty associated with the data gap for a developmental neurotoxicity study in rats. The 3x safety factor does not apply to occupational workers.

Cancer Determination

The carcinogenicity issue has been considered by the Health Effects Division-Cancer Peer Review Committee. The Committee agreed that "there was no evidence of carcinogenicity" for endosulfan.[1]

SUMMARY OF USE PATTERNS AND FORMULATIONS

Deletion of Uses

Since the previous version of the endosulfan occupational and residential risk assessment dated February 2, 2000, a 6f notice has been issued and finalized after a 30 day comment period.[4] The following uses have been deleted from the endosulfan technical labels at the request of the endosulfan task force and will not be assessed in this document:

- All home and residential uses
- Endosulfan in the form of fogger, insecticidal smoke, impregnated material, dust, pressurized liquid, and pressurized spray.
- Food: Citrus (except non-bearing and nursery stock), artichoke, safflower, sugar beet, watercress, alfalfa, clover/forage (except grown for seed), corn (field/forage), endive, evening primrose, garden beets, garlic, and rapeseed (canola).
- Non-food: Indoor household uses, wood protectant, unseasoned forest products, ULV application, Douglas Fir, Juniper, Locust, Maple, and Willow (forestry use), forestry plantings.
- Commercially Grown Greenhouse/Out-of-Doors Ornamental Plants (Except for Commercially Grown Outdoor Trees and Shrubs)–Including but not Limited to Aster, Carnation, Chrysanthemum, Evening Primrose, Iris, Lilies, Marigold, Poinsettia, Snapdragon, Tulips, Croft Lily, German Lily, Hydrangea, Periwinkle, Rhododendron, Rose, Rhododendron Canescens, Flowering Peach/Nectarine, Leatherleaf Fern, Holly Fern.

Occupational- and Non-Occupational-Use Products

At this time, products containing endosulfan are intended for occupational and residential uses. Residential uses will not be included in this assessment, because of the above mentioned deletion. Occupational uses include applications to agricultural food and non-food crops, ornamental and/or shade trees, fruit and nut crops, ornamental herbaceous trees, and shrubs.[5,6]

Type of Pesticide/Targeted Pests

Endosulfan [6, 7, 8, 9, 10-hexachloro-1, 5, 5a, 6, 9, 9a, hexahydro-6, 9-methano-2, 4, 3-benzodioxathiepin-3-oxide] is a broad spectrum insecticide/acaricide. Examples of the type of pests that endosulfan is used to control include (but are not limited to) the following:

- **Agricultural**: Meadow spittlebug, Army cutworm, Aphids, Bean leaf skeletonizer, Cowpea curculio, Cucumber beetle, Flea beetle, Green stink bug, Leafhoppers, Mexican bean beetles, Cabbage looper, Cabbage worm, Cabbage aphid, Cucumber beetles, Whitefly, Cutworms, Diamondback moth, Corn earworm, Boll weevil, Bollworm, Lygus bugs, Thrips, Melonworm, Pickleworm, Rindworm, Squash beetle, Squash bug, Blister beetle, Potato beetle, Rose chafer, Pepper maggot, Cinch bug, Crown mite, June bug, Harlequin bug, Grape phylloxera, and Grape leafhopper.

- **Orchards**: Aphids (including Apple aphids, Black cherry aphid, Black peach aphid, Green peach aphid, Rosy apple aphids, Rusty plum aphids, Wooly apple aphids), Apple rust mites, Green fruitworm, Tarnished plant bug, Tentiform leafminers, Whitefly leaf hoppers, Peachtree borer, Peach twig borer, Plum rust mite, Bud moth, Bud mites, Twig mites, Filbert aphid, Filbert leafroller, Filbert bud mite, Black pecan aphic, Pecan nut casebearer, and Spittlebug.

- **Ornamental Trees and Shrubs**: Leather leaf fern borer, Aphids, Cyclamen mite, Rose chafer, Whitefly, Dogwood borer, Lilac borer, Colley spruce gall adelgid, Douglas fir needle midge, Walnut aphid, and Stink bug.

Formulation Types and Percent Active Ingredient

Endosulfan is formulated for occupational use as a technical grade manufacturing product (95 percent active ingredient [ai]), emulsifiable concentrate (9 percent to 34 percent active ingredient), and a wettable powder (1 percent to 50 percent active ingredient).[5,6] The wettable powder is frequently packaged in water soluble bags.

Registered Use Sites

Occupational-Use Sites

Endosulfan has been registered for occupational-use on terrestrial food and feed crops, indoor food crops, and terrestrial non-food crops. For ease and brevity, the occupational crops use sites in this assessment have been grouped as follows:

- **Vegetables and Field Crops**: alfalfa (seed only), barley, beans (dry and succulent), blueberries, broccoli, brussel sprouts, cabbage, carrots, cauliflower, celery, clover (seed only), collards, cotton, corn (fresh only), cucumbers, eggplants, grapes, kale, kohlrabi (seed only), lettuce, melons, mustard greens, oats, peas, peppers, pineapples, potatoes, pumpkins, radish (seed only), rutabaga (seed only), rye, spinach, squash, sweet potatoes, strawberries, tobacco, tomato, turnip, and wheat.

- **Fruit and Nut Trees (orchard crops),** including apples, apricots, almonds, cherries, filberts, macadamia nuts, nectarines, pecans, peach, pear, plums, prunes, and walnuts.

- **Ornamental Trees and Shrubs,** including shade trees, citrus (non-bearing and nursery stock), shrubs, nursery stock, Christmas tree plantations, and woody plants.

- **Root dip,** including cherry, peaches, and plum roots and crowns, and whole strawberry plants.

- **Agriculture in greenhouses** (tomatoes and ornamental trees and shrubs).

Application rates[5,6]

The crop groupings with their corresponding maximum label application rates are as follows (both formulations unless noted, EC = emulsifiable concentrate, WP = wettable powder formulations):

- **Agricultural crops,** including vegetables and field crops: alfalfa (seed only, 1 lb ai/A EC), barley, rye, oats and wheat (0.75 lb ai/A), beans and tomatoes (1 lb ai/A), clover (0.5 lbs ai/A EC), blueberries (1.5 lb ai/A), broccoli, cabbage, collard, lettuce, melons, and mustard greens (1lb ai/A or 2 lb ai/A for seed), brussel sprouts, carrots, cauliflower, celery, cucumbers, eggplants, peas, peppers, potatoes, pumpkins, spinach, and squash (1 lb ai/A), cotton and corn (fresh only) (1.5 lb ai/A), grapes (1.5 lb ai/A or 0.005 lb ai/gallon), kale (0.75 lb ai/A or 2 lb ai/A for seed), kohlrabi, radish, turnip and rutabaga (2 lb ai/A seed only), pineapples and sweet potato (2 lb ai/A), and tobacco (1.5 lb ai/A WP, 3 lbs ai/A EC).

- **Fruit and nut trees (orchard crops),** including apples (2.5 lb ai/A or 0.0075 lb ai/gal), apricots, peach, and nectarines (3 lb ai/A or 0.0025 lb ai/gal), almonds (2.5 lb ai/A or 0/025 lb ai/gallon), cherries, pears, plums, and prunes (2.5 lb ai/A or 0.04 lb ai/gallon), filberts (hazelnuts 2lb ai/A or 0.005 lb ai/gallon), macadamia nuts and pecans (7.5lb ai/A or 0.075 lb ai/gallon), and walnuts (2 lb ai/A or 0.02 lb ai/gallon WP, 2.5 lb ai/A or 0.04 lb ai/gallon EC).

- **Ornamental Trees and Shrubs,** including shade trees, citrus (non-bearing and nursery stock), shrubs, nursery stock, Christmas tree plantations, and woody plants (1 lb ai/A or 0.01 lb ai/gallon).

- **Root dip,** including cherry, peaches, and plum roots and crowns (0.05 lb ai/gallon) and whole strawberry plants (0.01 lb ai/gallon EC).

- **Bark Treatment,** includes apricot, cherry, grapes, nectarines, peach, plums and prunes (see above for application rates, applied with high pressure handwands and rights-of-way sprayers).

Methods and Types of Equipment Used for Mixing, Loading, and Application

Equipment for commercial use includes groundboom sprayer, fixed-wing aircraft, chemigation (potatoes only), airblast sprayer, rights of way sprayer, low pressure handwand, high pressure handwand, backpack sprayer, and dip treatment.

OCCUPATIONAL EXPOSURE AND RISK ASSESSMENT/CHARACTERIZATION

Occupational Handler Exposures and Risks

Handler Scenarios

EPA has determined that there are potential exposures to mixers, loaders, applicators, and other handlers during usual use-patterns associated with endosulfan. Based on the use patterns, 21 major occupational exposure scenarios were identified for endosulfan: (1a) mixing/loading liquid formulations for aerial application; (1b) mixing/loading liquid formulation for chemigation; (1c) mixing/loading liquid formulations for groundboom application; (1d) mixing/loading liquid formulations for airblast application; (1e) mixing/loading liquid formulations for rights-of-way sprays; (1f) mixing/loading liquid formulations for plant and root dip; (2a) mixing/loading wettable powders for aerial application; (2b) mixing/loading wettable powders for groundboom application; (2c) mixing/loading wettable powders for airblast application; (2d) mixing/loading wettable powder for rights of way spray application; (2e) mixing/loading wettable powders for plant and root dip; (3) applying sprays with aerial equipment; (4) applying sprays with a groundboom sprayer; (5) applying sprays with an airblast sprayer; (6) applying sprays with a rights-of-way sprayer; (7) applying dip treatment to roots, or whole plants; (8) mixing/loading/applying liquids

with a low pressure hand wand; (9) mixing/loading/applying wettable powders with a low pressure handwand; (10) mixing/loading/applying liquids with a high pressure hand wand; (11) mixing/loading/applying liquids with backpack sprayer; and (12) flagging aerial spray applications.

Current endosulfan labels PPE requirements range from no PPE listed to long sleeved shirt and long pants, waterproof gloves, shoes, socks, chemical resistant headgear, respirator with either an organic vapor removing cartridge with a prefilter or canister approved for pesticides. Mixer and loaders must also wear a chemical resistant apron.

Handler Exposure Data - Chemical Specific Data

In support of the reregistration process for endosulfan, AgrEvo USA submitted a worker exposure study for review by EPA. The 1987 study, *Exposure of Mixer/Loader/ Applicators to Thiodan® 3EC Insecticide Applied to Fruit Trees by Airblast Equipment in California* was originally submitted as MRID No. 410485-02. The registrant subsequently made revisions and resubmitted the study in 1990 as MRID No. 417152-01. EPA determined that both the original and revised study do not meet Agency guidelines for acceptability under Subdivision U of the Pesticide Assessment Guidelines. The following data gaps and deficiencies were found[7]:

- **Study Design:** The study was conducted at 2 sites (3 replicates each) instead of 3 sites (5 replicates each), as required by Subdivision U of the Pesticide Assessment Guidelines. Also, it should be noted that the biological monitoring data are invalid because the main excretory pathway for endosulfan is through feces (media not monitored in study) and not the urine (media monitored in study). This was identified in the endosulfan reregistration standard.

- **Inhalation:** No air pump calibration/operation data were provided. Field recovery samples did not appear to be exposed to environmental conditions (i.e., no air was drawn through the charcoal tubes) during the actual field sampling trials. Breakthrough/volatilization validation data are lacking.

- **Dermal:** Hand wash field recovery sample results are low and highly variable. Also, 3 samples were lost and not analyzed concurrently with the remaining field samples. Since hand exposure accounts for a large percentage of the total exposure, the quality of the hand wash recovery samples are necessary to evaluate dermal exposure.

Based on these deficiencies, the data in MRIDs 410485-02 and 417152-01 are not used in the assessment. Instead, surrogate-based exposure assessments for each scenario, including airblast, were developed, where appropriate data were available, using the Pesticide Handlers Exposure Database (PHED) Version 1.1.[8]

The registrant also submitted a risk assessment titled, "Evaluation of the Human Hazards and Risks Associated with the Application of Endosulfan." dated March 1989 (MRID 410485-01).[9] This submission was not used in this risk assessment for the following reasons: the exposure data used was from the above study (MRID 417152-01) which was found to be unacceptable, acres treated per day used were not justified and vary widely from the HED standard values, and the monkey dermal penetration study which is critical in interpreting the biological monitoring data was not acceptable.

HED has reviewed Aventis' "Submission of an Application Exposure Assessment for Endosulfan and an Evaluation of Possible Endocrine Effects in Mammalian Species" dated August 4, 1999 (MRID 449391-01)[10] and concludes that the submission does not follow standard HED policies or use HED standard default values. HED calculates high-end single-day exposures to occupational workers, based on maximum label application rates and standard values for the number of acres that can be treated in a single day by various types of agricultural equipment. These standard acres treated per day values are representative of most crops treated with endosulfan, including both low (strawberries) and high (potatoes) acreage crops, and are protective of commercial applicators who may treat multiple farms or fields in one day. Although the 1992 U.S. Census of Agriculture data used by Aventis does represent the national average crop acreage per farm, it is only representative of individual farmers and not of commercial applicators, who are likely to treat more acres in a day than individual growers.

Aventis' exposure assessment incorporates a 50% reduction factor to dermal exposure for workers, based on the label requirement for chemical resistant headgear. HED does not assign a reduction factor to dermal exposure due to the use of chemical resistant headgear. Although HED agrees that chemical resistant headgear may reduce pesticide exposure, a protection factor has not been established for the use of such headgear. Therefore, HED does not quantitatively reduce exposure risk estimates to take chemical resistant headgear into account.

HED notes that the revised dermal endpoints are based on the 21-dermal study in the rat for all exposure durations. For any duration longer than 30 days, an additional 3x safety factor was added to account for using a 21-day study for a duration of longer than 30 days.[2] This study replaces the two-year chronic toxicity/carcinogenicity study in rats that was originally used to assess for intermediate-term dermal exposure. HED has considered Aventis' submission for inclusion in the endosulfan assessment, but because of the aforementioned discrepancies, it will not be included in this assessment.

Handler Exposure Data - Surrogate Data

Table 3 summarizes the caveats and parameters specific to the surrogate data used for each scenario and corresponding exposure/risk assessment. These caveats include the source of the data and an assessment of the overall quality of the data. The assessment of data quality is based solely on the number of observations and the available quality control data. The quality control data are based on a grading criteria established by the PHED Task Force.[11]

The PHED Task Force is comprised of representatives from the U.S. EPA, Health Canada, the California Department of Pesticide regulation, and member companies of the American Crop Protection Association. PHED is a software system consisting of two parts: a database of measured exposure values for workers involved in the handling of pesticides under actual field conditions and a set of computer algorithms used to subset and statistically summarize the selected data. Currently, the database contains values for over 1,700 monitored individuals (i.e., replicates).

Users select criteria to subset the PHED database to reflect the exposure scenario being evaluated. The subsetting algorithms in PHED are based on the central assumption that the magnitude of handler exposures to pesticides are primarily a function of activity (e.g., mixing/loading, applying), formulation type (e.g., wettable powders, granulars), application method (e.g., aerial, groundboom), and clothing scenarios (e.g., gloves, double layer clothing).

Once the data for a given exposure scenario have been selected, the data are normalized (i.e., divided by) by the amount of pesticide handled resulting in standard unit exposures (milligrams of exposure per pound of active ingredient handled). Following normalization, the data are statistically summarized. The distribution of exposure values for each body part (e.g., chest upper arm) is categorized as normal, lognormal, or "other" (i.e., neither normal nor lognormal). A central tendency value is then selected from the distribution of the exposure values for each body part. These values are the arithmetic mean for normal distributions, the geometric mean for lognormal distributions, and the median for all "other" distributions. Once selected, the central tendency values for each body part are composited into a "best fit" exposure value representing the entire body.

The unit exposure values calculated by PHED generally range from the geometric mean to the median of the selected data set. While data from PHED provide the best available information on handler exposures, it should be noted that some aspects of the included studies (e.g., duration, acres treated, pounds of active ingredient handled) may not accurately represent labeled uses in all cases. HED has developed a series of tables of standard unit exposure values for many occupational scenarios that can be utilized to ensure consistency in exposure assessments (PHED Surrogate Exposure Guide, August 1998)[8].

Handler Exposure Assumptions

The following assumptions and factors were used to complete this exposure assessment:

- Calculations were completed for a range of maximum application rates for specific crops recommended by the available endosulfan labels and the LUIS report. These rates were assessed in order to bracket risk levels associated with the various use patterns.
- Average body weight of an adult handler was assumed to be 70 kg.

- Daily (8-hour workday) acres and volumes (as appropriate) to be treated in each scenario include:[12]

  -- A range of the possible number of acres that can be treated with endosulfan aerially on cotton, small grains (wheat, barley, oats and rye),corn and alfalfa in one day are given in this assessment for risk mitigation decision purposes. Exposures were estimated for handlers using 1,200 and 350 acres per day for aerial equipment. The use of 1,200 acres treated in one day by either the mixer/loader or the applicator is considered a reasonable high end estimate, because these crops are high acreage field crops. This maximum acres treated aerially per day is based on published scientific literature, surveys, knowledge of agricultural practices, and calculated acreage estimates. Until actual use pattern data for endosulfan use on cotton, small grains, alfalfa, and corn are supplied, 1,200 acres maximum treated per day for either the aerial mixer/loader or the aerial applicator is considered to be a reasonable estimate.[12]

  -- 350 acres for aerial applications to all agricultural crops other than small grains (wheat, barley, oats and rye), cotton, corn and alfalfa;

  -- 350 acres for flaggers supporting aerial applications;

  -- For groundboom equipment use on cotton, small grains (wheat, barley, oats and rye), alfalfa and corn, since they are large acreage crops, a range of 200 acres per day to 80 acres per day was used. For all other crops, 80 acres was used.

  -- 40 acres for airblast applications on agricultural crops, and ornamentals;

  -- 1000 gallons for high pressure handwands and rights of way sprayers

  -- 40 gallons for low pressure handwands and backpack sprayers

- Due to a lack of scenario-specific data, HED sometimes calculates unit exposure values using generic protection factors that are applied to represent the use of personal protective equipment (PPE) and engineering controls. This assessment used a 50 percent protection factor to account for a double layer of clothing, and a 90 percent protection factor for over baseline inhalation unit exposure values to represent use of an organic vapor removing respirator (currently required on the label).

- The duration of exposure for handlers of endosulfan is assumed to be short-term only (one day to one month). This assumption should be confirmed with additional use data.

Handler Exposure Calculations

Handler exposure assessments were completed using a baseline exposure scenario and, if required, increasing levels of risk mitigation (PPE and engineering controls) in an attempt to achieve an appropriate margin of exposure. The baseline scenario generally represents a handler wearing long pants, a long-sleeved shirt, no respirator, and no chemical-resistant gloves (there are exceptions pertaining to the use of gloves, and these are noted). Baseline exposures are presented in Table 4. Table 5 includes short-term exposure/risk calculations for additional PPE and engineering controls. Table 6 summarizes the risks for all mitigation levels.

The calculations of daily dermal and inhalation exposure to endosulfan by handlers were used to calculate the daily dose, and therefore the risks, to those handlers. Daily dermal exposure was calculated using the following formula:

Daily Dermal Exposure [mg ai/day] = Unit Exposure [mg ai/lb ai] x Use Rate [lb ai/A] x Daily Acres or Daily Acres Treated or Gals Used [A/day or Gal/day]

Potential daily inhalation exposure was calculated using the following formula:

Daily Inhalation Exposure [mg ai/day] = Unit Exposure [μg ai/lb ai] x Conversion Factor [1 mg/1000 μg] x Use Rate [lb ai/A] x Daily Acres Treated or Gals Used [A/day or Gal/day]

The potential short-term inhalation and dermal doses were calculated using the following formulae:

Daily Inhalation Dose [mg ai/kg/day] = Daily Inhalation Exposure [mg ai/day] x [1/body weight (kg)]

Daily Dermal Dose [mg ai/kg/day] = Daily Dermal Exposure [mg ai/day] x [1/body weight (kg)]

Since the dermal endpoint was based on a dermal study, a dermal absorption factor is not necessary. The following formulae were used in the calculation of the short-term dermal and inhalation MOEs.

Dermal MOE = [Dermal NOAEL (mg/kg/day)] ÷ [Short-term Dermal Dose (mg/kg/day)]

Inhalation MOE = [Inhalation NOAEL (mg/kg/day)] ÷ [Short-term Inhalation Dose (mg/kg/day)]

A short-term dermal NOAEL of 3.0 mg/kg/day was used in the calculation of MOEs. The short-term inhalation NOAEL of 0.2 mg/kg/day was calculated by converting the inhalation NOAEL of 0.001 mg ai/L in Wistar rats. Dermal and inhalation MOEs were not aggregated because the end effects seen at the LOAEL were different.

The inhalation endpoint for short-term inhalation risks, 0.001 mg ai/L, was converted to an oral equivalent dose using the HED Route-to-Route Extrapolations memo[13] dated October 9, 1998, presented below:

Inhalation NOAEL (mg/kg/day) = [NOAEL (mg ai/L) x RV (L/hr) x D x A x AF x 5 days/week] ÷ BW x 7 days/week

where:

RV	=	respiratory volume (8.46 liters of air respired per hour at rest)
D	=	duration of daily animal exposure (based on a 6-hour/day study)
BW	=	mean body weight in kg of Wistar rat (0.187 kg)
A	=	absorption - the ratio of deposition and absorption in the respiratory tract compared to absorption by the oral route, assumed to be 1
AF	=	activity factor - animal default is 1

An MOE of 100 has been identified as the target risk level for short-term occupational exposure scenarios.

Table 3: Occupational Exposure Scenario Descriptions for the Use of Endosulfan

Exposure Scenario (Number)	Data Source	Standard Assumptions[a] (8-hr work day)	Comments[b]
Mixer/Loader Descriptors			
Mixing/Loading Liquid Formulations (1a/1b/1c/1d/1e/1f)	PHED V1.1	1200 acres for aerial application on small grains (wheat, barley, oats and rye), cotton, corn, and alfalfa, 350 acres for aerial application on all other crops and chemigation application; 200 acres for groundboom application to cotton, wheat, alfalfa, and corn, 80 acres for groundboom application to all other agricultural crops and 10 acres for ornamentals; 40 acres for airblast application and 1000 gallons for rights of way spray application to ornamentals and as a tree bark treatment.	**Baseline:** Hands, dermal, and inhalation = AB grades. Hands = 53 replicates; Dermal = 72 to 122 replicates; and Inhalation = 85 replicates. High confidence in hands/dermal, and inhalation data. No protection factor was needed to define the unit exposure value. **PPE:** The same dermal data are used as for baseline, coupled with a 50% protection factor to account for an additional layer of clothing, with gloved hand data. A 10-fold PF (i.e., 90% PF) was applied to the baseline inhalation data. Hands = AB grades. Hands = 59 replicates. High confidence in hands data. **Engineering Controls:** Hands, dermal, and inhalation = AB grades. Hands = 31 replicates; Dermal= 16 to 22; and Inhalation = 27 replicates. High confidence in hands/dermal, and inhalation data. No protection factor was needed to define the unit exposure value. Engineering controls based on closed mixing/loading.
Mixing/Loading Wettable Powder Formulations (2a/2b/2c/2d/2e)	PHED V1.1	1200 acres for aerial application on small grains (wheat, barley, oats and rye), cotton, corn, and alfalfa, 350 acres for aerial application on all other crops and chemigation application; 200 acres for groundboom application to cotton, wheat, alfalfa, and corn, 80 acres for groundboom application to all other agricultural crops and 10 acres for ornamentals; 40 acres for airblast application and 1000 gallons for rights of way spray application to ornamentals and as a tree bark treatment.	**Baseline:** Hands, dermal, and inhalation = ABC grades. Hands = 7 replicates; Dermal = 22 to 45 replicates; and Inhalation = 44 replicates. Low confidence in hands/dermal, and medium confidence in inhalation data. No protection factor was needed to define the unit exposure value. **PPE:** The same dermal data are used as for baseline, coupled with a 50% protection factor to account for an additional layer of clothing, with gloved hand data. A 10-fold PF (i.e., 90% PF) was applied to the baseline inhalation data. Hands = ABC grades. Hands = 24 replicates. Medium confidence in hands data. **Engineering Controls**: Hands = AB grades; dermal and inhalation = all grades. Hands = 5 replicates; Dermal = 6 to 15 replicates; and Inhalation = 15 replicates. Low confidence in the hands, dermal and inhalation data. No protection factor was needed to define the unit exposure value. Engineering controls are based on water soluble packets.
Applicator Descriptors			
Applying Sprays with Aerial Equipment (3)	PHED V1.1	1200 acres for aerial application on small grains (wheat, barley, oats and rye), cotton, corn, and alfalfa and 350 acres for aerial application on all other crops	**Engineering Controls:** Hands = AB grade, dermal and inhalation = ABC grade. Hands= 34 replicates, dermal = 24 to 48 replicates, and inhalation = 23 replicates. Medium confidence in hands, dermal, and inhalation data. No protection factor was needed to define the unit exposure value.
Applying Sprays with a Groundboom Sprayer (4)	PHED V1.1	200 acres for groundboom application to cotton, small grains (wheat, barley, oats and rye), alfalfa, and corn, 80 acres for groundboom application to all other agricultural crops and 10 acres for ornamentals.	**Baseline**: Hands, dermal, and inhalation = AB grades. Hands = 29 replicates, dermal = 23 to 42 replicates, and inhalation = 22 replicates. High confidence in hands, dermal, and inhalation data. No protection factor was needed to define the unit exposure value. **PPE**: The same dermal data are used as for baseline, coupled with a 50% protection factor to account for an additional layer of clothing, with gloved hand data. Hands = ABC grade, 21 replicates, and medium confidence. A 10-fold (i.e., 90% PF) was applied to the baseline inhalation data to account for the use of an organic vapor removing respirator. **Engineering Controls**: Dermal and hands = ABC grades. Hands = 16 replicates, dermal = 20-31 replicates. Medium confidence in both hands and dermal. Inhalation is AB grade, 16 replicates, and high confidence.

Table 3: Occupational Exposure Scenario Descriptions for the Use of Endosulfan (Continued)

Exposure Scenario (Number)	Data Source	Standard Assumptions[a] (8-hr work day)	Comments[b]
Applying Sprays with an Airblast Sprayer (5)	PHED V1.1	40 acres for application to fruit/nut and ornamental trees	**Baseline:** Hands, dermal , and inhalation = AB grades. Hands = 22 replicates, dermal = 32 to 49 replicates, and inhalation = 47 replicates. High confidence in hands, dermal, and inhalation data. No protection factor was needed to define the unit exposure value. **PPE:** The same dermal data are used as for baseline, coupled with a 50% protection factor to account for an additional layer of clothing, with gloved hand data. A 10-fold PF (i.e., 90% PF) was applied to the baseline inhalation data. Hands = AB grades. Hands = 18 replicates. High confidence in hands data. **Engineering Controls:** Hands and dermal = AB grade, and inhalation = ABC grade. Back calculated from glove data assuming gloves provide 90% protection. Dermal = 27 to 30 replicates; and inhalation = 9 replicates. Low confidence in dermal data; and low confidence in inhalation data (based on low replicates).
Applying Sprays with a Rights of Way Sprayer (6)	PHED V1.1	1000 gallons for application to trees in city streets, or as a tree bark treatment.	**Baseline:** Hand data are AB grade, dermal data are ABC grade, and inhalation data are A grades. Hand = 16 replicates; dermal = 4 to 20 replicates; and inhalation = 16 replicates. Low confidence in hand/dermal data, and high confidence in inhalation data. No protection factor was needed to define the unit exposure value. **PPE:** The same dermal data are used as for the baseline, coupled with a 50% protection factor to account for an additional layer of clothing, and chemical resistant glove data were used for hands. Hand data are AB grades with 4 replicates and low confidence level. The same inhalation data are used as for the baseline coupled with an 90% protection factor to account for the use of an organic vapor removing respirator. **Engineering Controls:** Not feasible for this scenario.
Applying Dip Treatment to Roots, or Whole Plants (7)	No Data	100 gallons for root dip, and whole strawberry plant dip	No Data
Mixer/Loader/Applicator Descriptors			
Mixing/Loading/Applying Liquids with a Low Pressure Handwand (8)	PHED V1.1	40 gallons for treatment to agricultural crops, including greenhouse crops and tobacco seed bed drench; bark treatment of dormant fruit trees; and indoor and outdoor ornamental treatment	**Baseline**: Dermal and inhalation = ABC grades; hands= all grades. Dermal = 9 to 80 replicates, inhalation = 80 replicates, and hands = 70 replicates. Low confidence in hands and dermal; and medium confidence in inhalation data. No protection factor was needed to define the unit exposure value. **PPE**: The same dermal data are used as for baseline coupled with a 50% protection factor to account for an additional layer of clothing. A 10-fold PF (i.e., 90% PF) was applied to the baseline inhalation data. Hands = ABC grades. Hands = 10 replicates. Low confidence in hands data. **Engineering Controls**: Not feasible for this scenario.
Mixing/Loading/Applying Wettable Powders with a Low Pressure Handwand (9)	PHED V1.1	40 gallons for treatment to agricultural crops, including greenhouse crops and tobacco seed bed drench; bark treatment of dormant fruit trees; and indoor and outdoor ornamental treatment	**Baseline:** Hand data are AB grades, dermal are ABC grades, and inhalation data are ABC grades. Hand = 15 replicates, back calculated from glove data assuming a 90% protection factor from gloves; dermal = 16 replicates; and inhalation = 16 replicates. Low confidence in dermal, and medium confidence in hand and inhalation data. No protection factor was needed to define the unit exposure value. **PPE:** The same dermal are used as for the baseline, coupled with a 50% protection factor to account for an additional layer of clothing. The same inhalation data as for baseline are used, coupled with an 90% protection factor to account for the use of an organic vapor removing respirator. **Engineering Controls:** Not feasible for this scenario.

Table 3: Occupational Exposure Scenario Descriptions for the Use of Endosulfan (Continued)

Exposure Scenario (Number)	Data Source	Standard Assumptions[a] (8-hr work day)	Comments[b]
Mixing/Loading/Applying Liquids using High Pressure Sprayer (10)	PHED V1.1	1000 gallons for treatment to agricultural crops, bark treatment of dormant fruit trees; and indoor and outdoor ornamental treatment	**Baseline:** Hands = C grade; dermal = AB grades; and inhalation = A grades. Hands = 13 replicates, back calculated from glove data using a 90% protection factor; dermal = 7 to 13 replicates; and inhalation= 13 replicates. Low confidence in hands, dermal and inhalation data. No protection factor was needed to define the unit exposure. **PPE:** The same dermal data are used as for baseline, coupled with a 50% protection factor to account for an additional layer of clothing. The same inhalation data as for baseline are used, coupled with a 90% protection factor to account for the use of a organic vapor removing respirator. **Engineering Controls:** Not feasible for this scenario.
Mixing/Loading/Applying Liquids with a Backpack Sprayer (11)	PHED V1.1	40 gallons for treatment to agricultural crops, including greenhouse crops and tobacco seed bed drench; bark treatment of dormant fruit trees; and indoor and outdoor ornamental treatment	**Baseline**: No data for dermal and hands. Inhalation= A grade. Inhalation= 11 replicates. Low confidence in inhalation data. **PPE**: Dermal= AB grade and hands= C grade. Dermal= 9 to 11 replicates, and hands = 11 replicates. Low confidence in dermal and hands data. A 10-fold PF (i.e., 90% PF) was applied to the baseline inhalation data. A 50% PF was applied to dermal to account for double layer clothing. **Engineering Controls**: Not feasible for this scenario.
Flagger Descriptors			
Flagging Aerial Spray Applications (12)	PHED V1.1	350 acres	**Baseline:** Hands, dermal, and inhalation = AB grades. Dermal = 18 to 28 replicates; Hands = 30 replicates; and Inhalation = 28 replicates. High confidence in dermal, hands, and inhalation data. **PPE**: The same dermal data are used as for baseline coupled with a 50% protection factor to account for an additional layer of clothing. Hands = AB grades. Hands= 6 replicates. Low confidence in hands data. A 10-fold PF (i.e., 90% PF) was applied to the baseline inhalation data to account for the use of an organic vapor removing respirator. **Engineering Controls**: Enclosed groundboom data are used as a surrogate for engineering controls for flaggers. Dermal and hands = ABC grades; Inhalation = AB grades. Dermal = 20 to 31 replicates; Hands = 16 replicates; and Inhalation = 16 replicates. Medium confidence in dermal and hands data. High confidence in inhalation data.

Footnotes:

a Standard Assumptions based on an 8-hour work day as estimated by HED. BEAD data were not available.

b "Best Available" grades are defined by OREB SOP for meeting Subdivision U Guidelines. Best available grades are assigned as follows: matrices with grades A and B data and a minimum of 15 replicates; if not available, then grades A, B and C data and a minimum of 15 replicates; if not available, then all data regardless of the quality and number of replicates. Data confidence are assigned as follows:

High = grades A and B and 15 or more replicates per body part
Medium = grades A, B, and C and 15 or more replicates per body part
Low = grades A, B, C, D and E or any combination of grades with less than 15 replicates

Table 4. Short-term Occupational Risk to Endosulfan at Baseline

Exposure Scenario (Scenario #)	Baseline Dermal Unit Exposure (mg/lb ai)[a]	Baseline Inhalation Unit Exposure (µg/lb ai)[b]	Crop Type/Use[c]	Range of Application Rates (lb ai/A)[d]	Amount Handled per Day[e]	Daily Dermal Dose (mg/kg/day)[f]	Daily Inhalation Dose (mg/kg/day)[g]	Dermal MOE[h]	Inhalation MOE[i]
Mixer/Loader Exposures									
Mixing/Loading Liquid Formulations for Aerial Application (1a)	2.9	1.2	clover	0.5 lb ai/A	350 Acres	7.3	0.003	0.41	67
			tobacco	2.5 lb ai/A		36	0.015	0.083	13
			pecans	7.5 lb ai/A		110	0.045	0.028	4
			small grains	0.75 lb ai/A	1200 Acres	37	0.015	0.08	13
			cotton	1.5 lb ai/A		75	0.031	0.04	7
Mixing/Loading Liquid Formulation for Chemigation (1b)	2.9	1.2	potatoes (Idaho)	1.0 lb ai/A	350 Acres	15	0.0060	0.21	33
Mixing/Loading Liquid Formulations for Groundboom Application (1c)	2.9	1.2	clover	0.5 lb ai/A	80 Acres	2	0.00069	2	290
			tobacco	2.5 lb ai/A		8	0.0034	0.36	58
			small grains	0.75 lb ai/A	200 Acres	6	0.0026	0.48	78
			cotton	1.5 lb ai/A		12	0.0051	0.24	39
Mixing/Loading Liquid Formulations for Airblast Application (1d)	2.9	1.2	Ornamental Trees/Shrubs	1.0 lb ai/A	40 Acres	2	0.00069	2	290
			hazelnuts	2.0 lb ai/A		3	0.0014	0.91	150
			pecans	7.5 lb ai/A		12	0.0051	0.24	39
Mixing/Loading Liquids for Rights of Way Spray Application (1e)	2.9	1.2	grapes	0.005 lb ai/gal	1000 Gallons	0.21	0.000086	14	2300
			cherry	0.04 lb ai/gal		2	0.00069	1.8	290
Mixing/Loading Liquids for Plant and Root Dip (1f)	2.9	1.2	cherry, peach and plums	0.05 lbs ai/gal	100 Gallons	0.21	0.000086	14	2300
Mixing/Loading Wettable Powders for Aerial Application (2a)	3.7	43	beans	1.0 lb ai/A	350 Acres	19	0.22	0.16	0.93
			sweet potato	2.0 lb ai/A		37	0.43	0.081	0.47
			peach	3.0 lb ai/A		56	0.65	0.054	0.31
			small grains	0.75 lb ai/A	1200 Acres	48	0.55	0.063	0.36
			cotton	1.5 lb ai/A		95	1.1	0.032	0.18

Table 4. Short-term Occupational Exposures to Endosulfan at Baseline (continued)

Exposure Scenario (Scenario #)	Baseline Dermal Unit Exposure (mg/lb ai)[a]	Baseline Inhalation Unit Exposure (µg/lb ai)[b]	Crop Type/Use[c]	Range of Application Rates (lb ai/A)[d]	Amount Handled per Day[e]	Daily Dermal Dose (mg/kg/day)[f]	Daily Inhalation Dose (mg/kg/day)[g]	Dermal MOE[h]	Inhalation MOE[i]
Mixing/Loading Wettable Powders for Groundboom Application (2b)	3.7	43	beans	1.0 lb ai/A	80 Acres	4.2	0.049	0.71	4
			sweet potato	2.0 lb ai/A		8.5	0.098	0.35	2
			small grains	0.75 lb ai/A	200 Acres	7.9	0.092	0.38	2
			cotton	1.5 lb ai/A		16	0.18	0.19	1
Mixing/Loading Wettable Powders for Airblast Application (2c)	3.7	43	Ornamental Trees/Shrubs	1.0 lb ai/A	40 Acres	2.1	0.025	1.4	8
			hazelnuts	2.0 lb ai/A		4.2	0.049	0.71	4
			peaches	3.0 lb ai/A		6.3	0.074	0.47	3
Mixing/Loading Wettable Powders for Rights of Way Spray Treatment (2d)	3.7	43	grapes	0.005 lb ai/gal	1000 Gallons	0.26	0.0031	11	65
			walnut	0.02 lb ai/gal		1.1	0.012	3	16
Mixing/Loading Wettable Powders for Plants and Root Dip (1e)	3.7	43	cherry, peach, and plum	0.05 lb ai/gal	100 Gallons	0.26	0.0031	11	65
Applicator Exposures									
Applying Spray with Aerial Equipment (3)	See Eng. Controls	See Eng. Controls	clover	0.5 lb ai/A	350 Acres	See Eng. Controls	See Eng. Controls	See Eng. Controls	See Eng. Controls
			tobacco	2.5 lb ai/A					
			pecans	7.5 lb ai/A					
			small grains	0.75 lb ai/A	1200 Acres				
			cotton	1.5 lb ai/A					
Applying Sprays with a Groundboom Sprayer (4)	0.014	0.74	clover	0.5 lb ai/A	80 Acres	0.008	0.00042	380	470
			tobacco	2.5 lb ai/A		0.04	0.0021	75	95
			small grains	0.75 lb ai/A	200 Acres	0.03	0.0016	100	130
			cotton	1.5 lb ai/A		0.06	0.0032	50	63
Applying Sprays with an Airblast Sprayer (5)	0.36	4.5	ornamental trees	1.0 lb ai/A	40 Acres	0.21	0.0026	15	78
			hazelnuts	2.0 lb ai/A		0.41	0.0051	7.3	39
			pecans	7.5 lb ai/A		1.5	0.019	2	10

Table 4. Short-term Occupational Exposures to Endosulfan at Baseline (continued)

Exposure Scenario (Scenario #)	Baseline Dermal Unit Exposure (mg/lb ai)[a]	Baseline Inhalation Unit Exposure (µg/lb ai)[b]	Crop Type/Use[c]	Range of Application Rates (lb ai/A)[d]	Amount Handled per Day[e]	Daily Dermal Dose (mg/kg/day)[f]	Daily Inhalation Dose (mg/kg/day)[g]	Dermal MOE[h]	Inhalation MOE[i]
Applying Sprays with a Rights of Way Sprayer (6)	1.3	3.9	grapes	0.005 lb ai/gal	1000 Gallons	0.093	0.00028	32	720
			cherries	0.04 lb ai/gal		0.74	0.0022	4	90
Applying Dip Treatment to Roots, or Whole Plants (7)	No Data	No Data	cherry, peach, plum roots	0.05 lb ai/gal	100 Gallons	No Data	No Data	No Data	No Data
Mixer/Loader/Applicator Exposure									
Mixing/Loading/Applying Liquid Formulations with a Low Pressure Handwand (8)	100	30	tobacco (drench)	0.005 lb ai/gal	40 Gallons	0.29	0.000086	11	2300
			tomato (greenhouse)	0.01 lb ai/gal		0.57	0.00017	5	1200
			cherries	0.04 lb ai/A		2.3	0.00069	1.3	290
Mixing/Loading/Applying Wettable Powders with a Low Pressure Handwand (9)	29	1,100	tomato/ tobacco	0.005 lb ai/gal	40 Gallons	0.083	0.0031	36	64
			walnut	0.02 lb ai/gal		0.33	0.013	9	16
Mixing/Loading/Applying Liquid with a High Pressure Handwand (10)	3.5	120	tobacco (drench)	0.005 lb ai/gal	40 Gallons	0.25	0.0086	12	23
			tomato (greenhouse)	0.01 lb ai/gal		0.5	0.017	6	12
			cherries	0.04 lb ai/A		2.0	0.069	1.5	3
Mixing/Loading/Applying Liquid with Backpack Sprayer (11)	2.5	30	tobacco (drench)	0.005 lb ai/gal	40 Gallons	0.0071	0.000086	420	2300
			tomato (greenhouse)	0.01 lb ai/gal		0.014	0.00017	210	1200
			cherries	0.04 lb ai/A		0.057	0.00069	53	290
Flagger Exposures									
Flagging Aerial Spray Applications (12)	0.011	0.35	clover	0.5 lb ai/A	350 Acres	0.027	0.00088	110	230
			tobacco	2.5 lb ai/A		0.14	0.0044	22	46
			pecans	7.5 lb ai/A		0.41	0.013	7	15

Footnotes:

a Baseline dermal unit exposure represents long pants, long sleeved shirt, no gloves, open mixing/loading, open cab/tractor. Values from PHED Surrogate Exposure Guide - August 1998.

b Baseline inhalation unit exposure represents no respirator. PHED Surrogate Exposure Guide - August 1998.

c Crops named are index crops which are chosen to represent all other crops at or near that application rate for that use. See the application rates listing in the use summary section of this document for further information on application rates used in this assessment.

d Application rates assessed are a range of maximum application rates found on endosulfan labels and the LUIS report. The rates are meant to bracket listed maximum application rates.

e Daily acres treated are based on Science Advisory Council for Exposure Policy # 9.[12]

f Baseline Dermal Dose (mg/kg/day) = (Dermal Unit Exposure (mg/lb ai) * Application rate (lb ai/acre) * Acres treated (acres/day)) / Body weight (70 kg).

g Baseline Inhalation Dose (mg/kg/day) = (Inhalation Unit Exposure (µg/lb ai) * (1mg/1000 µg) Conversion factor * Application rate (lb ai/A) * Acres treated (acres/day)) / Body weight (70 kg).

h Dermal MOE = Dermal NOAEL (3 mg/kg/day)/Short Term Dermal Dose (mg/kg/day). Short-term Target MOE = 100.

i Inhalation MOE = Inhalation NOAEL (0.2 mg/kg/day)/ Daily Inhalation Dose (mg/kg/day). Short-term Target MOE = 100.

Table 5. Occupational Short-term Risks from Endosulfan with Mitigation

Exposure Scenario (Scenario #)	Crop Type/Use	Additional PPE						Engineering Controls					
		Dermal Unit Exposure (mg/ lb ai)[a]	Daily Dermal Dose (mg/kg /day)[b]	Dermal MOE[c]	Inhalation Unit Exposure (g/ lbs ai)[d]	Daily Inhalation Dose (mg/kg/ day)[e]	Inhalation MOE[f]	Dermal Unit Exposure (mg/lb ai)[g]	Daily Dermal Dose (mg/kg/day)[b]	Dermal MOE[c]	Inhalation Unit Exposure (g/ lbs ai)[g]	Daily Inhalation Dose (mg/kg/ day)[e]	Inhalation MOE[f]
Mixer/Loader Exposures													
Mixing/Loading Liquid Formulations for Aerial Application (1a)	clover	0.017	0.043	71	0.12	0.0003	670	0.0086	0.021	140	0.083	0.00021	-
	tobacco		0.21	14		0.0015	130		0.11	**28**		0.001	-
	pecans		0.64	5		0.0045	44		0.32	**10**		0.0031	**64**
	small grains		0.22	14		0.0015	130		0.11	**27**		0.0011	-
	cotton		0.44	7		0.0031	65		0.22	**14**		0.0021	**94**
Mixing/Loading Liquid Formulation for Chemigation (1b)	potatoes (Idaho)	0.017	0.085	35	0.12	0.0006	330	0.0086	0.043	**70**	0.083	0.00042	-
Mixing/Loading Liquid Formulations for Groundboom Application (1c)	clover	0.017	0.0097	310	0.12	0.000069	-	0.0086	0.0049	-	0.083	0.000047	-
	tobacco		0.049	62		0.00034	580		0.025	120		0.00024	-
	small grains		0.036	82		0.00026	780		0.018	160		0.00018	-
	cotton		0.073	41		0.00051	390		0.037	**81**		0.00036	-
Mixing/Loading Liquid Formulations for Airblast Application (1d)	Ornamental Trees/Shrubs	0.017	0.0097	310	0.12	0.000069	-	0.0086	0.0049	-	0.083	0.000047	-
	hazelnuts		0.019	150		0.00014	-		0.0098	-		0.000095	-
	pecans		0.073	41		0.00051	390		0.037	**81**		0.00036	-
Mixing/Loading Liquids for Rights of Way Spray Application (1e)	grapes	0.017	0.0012	2500	0.12	0.0000086	-	0.0086	0.00061	-	0.083	0.0000059	-
	cherry		0.0097	310		0.000069	-		0.0049	-		0.000047	-
Mixing/Loading Liquids for Plant and Root Dip (1f)	peach, plum, cherry roots	0.017	0.0012	2500	0.12	0.0000086	-	0.0086	0.00061	-	0.083	0.0000059	-
Mixing/Loading Wettable Powders for Aerial Application (2a)	beans	0.13	0.65	5	4.3	0.021	10	0.0098	0.049	**61**	0.24	0.0012	170
	sweet potato		1.3	2		0.043	5		0.098	**31**		0.0024	**83**
	peach		2.0	1.5		0.065	3		0.15	**20**		0.0036	**56**
	small grains	0.13	1.7	2	4.3	0.055	4	0.0098	0.13	**24**	0.24	0.0031	**65**
	cotton		3.3	1		0.11	2		0.25	**12**		0.0062	**32**

Table 5. Occupational Short-term Risks from Endosulfan with Mitigation (continued)

Exposure Scenario (Scenario #)	Crop Type/Use	Additional PPE						Engineering Controls					
		Dermal Unit Exposure (mg/ lb ai)[a]	Daily Dermal Dose (mg/kg /day)[b]	Dermal MOE[c]	Inhalation Unit Exposure (g/ lbs ai)[d]	Daily Inhalation Dose (mg/kg/ day)[e]	Inhalation MOE[f]	Dermal Unit Exposure (mg/lb ai)[g]	Daily Dermal Dose (mg/kg/day)[b]	Dermal MOE[c]	Inhalation Unit Exposure (g/ lbs ai)[g]	Daily Inhalation Dose (mg/kg/ day)[e]	Inhalation MOE[f]
Mixing/Loading Wettable Powders for Groundboom Application (2b)	beans	0.13	0.15	20	4.3	0.0049	41	0.0098	0.011	270	0.24	0.00027	730
	sweet potato		0.3	10		0.0098	20		0.022	130		0.00055	360
	small grains		0.28	11		0.0092	22		0.021	140		0.00051	390
	cotton		0.56	5		0.018	11		0.042	**71**		0.001	190
Mixing/Loading Wettable Powders for Airblast Application (2c)	Ornamental Trees/Shrubs	0.13	0.074	40	4.3	0.0025	81	0.0098	0.0056	540	0.24	0.00014	1500
	hazelnuts		0.15	20		0.0049	41		0.011	270		0.00027	730
	peaches		0.22	13		0.0074	27		0.017	270		0.00041	490
Mixing/Loading Wettable Powders for Rights of Way Spray Treatment (2d)	grapes	0.13	0.0093	320	4.3	0.00031	650	0.0098	0.0007	-	0.24	0.000017	-
	walnut		0.037	81		0.0012	160		0.0028	1100		0.000069	-
Mixing/Loading Wettable Powders for Plant and Root Dip (2e)	cherry, peach, plum roots	0.13	0.0093	320	4.3	0.00031	650	0.0098	0.0007	-	0.24	0.000017	-
Applicator Exposures													
Applying Spray with Aerial Equipment (3)	clover	See Eng. Controls	See Eng. Controls	See Eng. Controls	See Eng. Controls	See Eng. Controls	See Eng. Controls	0.005	0.013	240	0.068	0.00017	1200
	tobacco								0.063	**48**		0.00085	240
	pecans								0.19	**16**		0.0026	**78**
	small grains								0.064	**47**		0.00087	230
	cotton								0.13	**23**		0.0017	110
Applying Sprays with a Groundboom Sprayer (4)	clover	0.011	0.0063	-	0.074	0.000042	-	0.005	0.0029	-	0.043	0.000025	-
	tobacco		0.031	95		0.00021	950		0.014	210		0.00012	-
	small grains		0.024	-		0.00016	-		0.011	-		0.000092	-
	cotton		0.047	64		0.00032	630		0.021	140		0.00018	-
Applying with an Airblast Sprayer (5)	ornamental trees	0.22	0.13	24	0.45	0.00026	780	0.019 (gloves)	0.011	280	0.45	0.00026	-
	hazelnuts		0.25	12		0.00051	390		0.022	140		0.00051	-
	pecans		0.94	3		0.0019	100		0.081	**37**		0.0019	-

Table 5. Occupational Short-term Risks from Endosulfan with Mitigation (continued)

Exposure Scenario (Scenario #)	Crop Type/Use	Additional PPE						Engineering Controls					
		Dermal Unit Exposure (mg/ lb ai)[a]	Daily Dermal Dose (mg/kg /day)[b]	Dermal MOE[c]	Inhalation Unit Exposure (g/ lbs ai)[d]	Daily Inhalation Dose (mg/kg/ day)[e]	Inhalation MOE[f]	Dermal Unit Exposure (mg/lb ai)[g]	Daily Dermal Dose (mg/kg/day)[b]	Dermal MOE[c]	Inhalation Unit Exposure (g/ lbs ai)[g]	Daily Inhalation Dose (mg/kg/ day)[e]	Inhalation MOE[f]
Applying Sprays with a Rights of Way Sprayer (6)	grapes	0.29	0.021	140	0.39	0.000028	-	NA	NA	NA	NA	NA	NA
	cherries		0.17	18		0.00022	900		NA	NA		NA	NA
Applying Dip Treatment to Roots, or Whole Plants (7)	cherry, peach, plum roots	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mixer/Loader/Applicator Exposure													
Mixing/Loading/Applying Liquids with a Low Pressure Handwand (8)	tobacco (drench)	0.37	0.0011	2800	3	0.000086	-	NA	NA	NA	NA	NA	NA
	tomato (greenhouse)		0.0021	1400		0.000017	-		NA	NA		NA	NA
	cherries		0.0085	350		0.000069	-		NA	NA		NA	NA
Mixing/Loading/Applying Wettable Powders with a Low Pressure Handwand (9)	tomato/ tobacco	6.2	0.018	170	110	0.00031	640	NA	NA	NA	NA	NA	NA
	walnut		0.071	**42**		0.0013	160		NA	NA		NA	NA
Mixing/Loading/Applying Liquids with a High Pressure Handwand (10)	tobacco (drench)	1.6	0.11	**26**	12	0.00086	230	NA	NA	NA	NA	NA	NA
	tomato (greenhouse)		0.23	**13**		0.0017	120		NA	NA		NA	NA
	cherries		0.91	**3**		0.0069	**29**		NA	NA		NA	NA
Mixing/Loading/Applying Liquids with Backpack Sprayer (11)	tobacco (drench)	1.6	0.0046	-	3	0.000086	-	NA	NA	NA	NA	NA	NA
	tomato (greenhouse)		0.0091	-		0.000017	-		NA	NA		NA	NA
	cherries		0.037	**82**		0.000069	-		NA	NA		NA	NA
Flagger Exposures													
Flagging Aerial Spray Applications (12)	clover	0.01	0.025	-	0.035	0.000087	-	0.00022	0.00055	-	0.007	0.000017	-
	tobacco		0.13	24		0.00044	460		0.0028	1100		0.000087	-
	pecans		0.38	8		0.0013	150		0.0083	360		0.00027	-

Footnotes:

a PPE dermal unit exposure values represents double layer of clothing and chemical resistant gloves, open mixing/loading, and open cab tractor.

b Daily Dermal Dose (mg/kg/day) = ((Dermal Unit Exposure (mg/lb ai) x Application Rates (lb ai/A and lb ai/gallon.) x Area Treated per day (acres or gallons)) / Body Weight (60 kg)) .

c Short-term PPE dermal MOE = short-term dermal NOAEL (3.0 mg/kg/day) / dermal dose (mg/kg/day). Target MOE = 100.

d PPE inhalation unit exposure represents use of organic vapor removing respirator.

e Daily Inhalation Dose = ((Inhalation Unit Exposure (g/lb ai) x Application Rates (lb ai/A and lb ai/gallon) x Area Treated per day (acres or gallons)* (1 mg/1000 g)) / Body Weight (70 kg))

f Short-term inhalation MOE = short-term inhalation NOAEL (0.2 mg/kg/day) /inhalation dose (mg/kg/day). Short-term Target MOE = 100.

g Engineering Controls dermal and inhalation unit exposure values represent:

1a/ b/c/d/e/f	Closed mixing and loading via mechanical transfer, single layer clothes, and chemical resistant gloves..
2a/b/c/d/e	Formulation packaged in water soluble bags, single layer clothes, and chemical resistant gloves.
3, 4, 5, 12	Enclosed cockpit, cab or truck, single layer clothes, and no gloves, except for airblast application, which includes gloves.
6, 7, 8, 9, 10, 11	No feasible engineering controls

- Scenario's calculated MOE exceeds the target MOE at the previous level of mitigation. (MOE > 100)

Bolded MOE values show a risk of concern at the highest possible level of mitigation for the corresponding scenario.

Table 6. Summary of Occupational Handler Risks to Endosulfan

Exposure Scenario (Scenario #)	Crop Type/Use[a]	Range of Application Rates (lb ai/A)[b]	Amount Handled per Day[c]	Baseline[f]		Additional PPE[g]		Engineering Controls[h]	
				Dermal MOE[d]	Inhalation MOE[e]	Dermal MOE[d]	Inhalation MOE[e]	Dermal MOE[d]	Inhalation MOE[e]
Mixer/Loader Exposures									
Mixing/Loading Liquid Formulations for Aerial Application (1a)	clover	0.5 lb ai/A	350 Acres	0.41	67	71	670	140	-
	tobacco	2.5 lb ai/A		0.083	13	14	130	**28**	-
	pecans	7.5 lb ai/A		0.028	4	5	44	**10**	**64**
	small grains	0.75 lb ai/A	1200 Acres	0.08	13	14	130	**27**	-
	cotton	1.5 lb ai/A		0.04	7	7	65	**14**	**94**
Mixing/Loading Liquid Formulation for Chemigation (1b)	potatoes (Idaho)	1.0 lb ai/A	350 Acres	0.21	33	35	330	**70**	-
Mixing/Loading Liquid Formulations for Groundboom Application (1c)	clover	0.5 lb ai/A	80 Acres	2	290	310	-	-	-
	tobacco	2.5 lb ai/A		0.36	58	62	580	120	-
	small grains	0.75 lb ai/A	200 Acres	0.48	78	82	780	160	-
	cotton	1.5 lb ai/A		0.24	39	41	390	**81**	-
Mixing/Loading Liquid Formulations for Airblast Application (1d)	Ornamental Trees/Shrubs	1.0 lb ai/A	40 Acres	2	290	310	-	-	-
	hazelnuts	2.0 lb ai/A		0.91	150	150	-	-	-
	pecans	7.5 lb ai/A		0.24	39	41	390	**81**	-
Mixing/Loading Liquids for Rights of Way Spray Application (1e)	grapes	0.005 lb ai/gal	1000 Gallons	14	2300	2500	-	-	-
	cherry	0.04 lb ai/gal		1.8	290	310	-	-	-
Mixing/Loading Liquids for Plant and Root Dip (1f)	cherry, peach and plums	0.05 lbs ai/gal	100 Gallons	14	2300	2500	-	-	-
Mixing/Loading Wettable Powders for Aerial Application (2a)	beans	1.0 lb ai/A	350 Acres	0.16	0.93	5	10	**61**	170
	sweet potato	2.0 lb ai/A		0.081	0.47	2	5	**31**	**83**
	peach	3.0 lb ai/A		0.054	0.31	1.5	3	**20**	**56**
	small grains	0.75 lb ai/A	1200 Acres	0.063	0.36	2	4	**24**	**65**
	cotton	1.5 lb ai/A		0.032	0.18	1	2	**12**	**32**
Mixing/Loading Wettable Powders for Groundboom Application (2b)	beans	1.0 lb ai/A	80 Acres	0.71	4	20	41	270	730
	sweet potato	2.0 lb ai/A		0.35	2	10	20	130	360
	small grains	0.75 lb ai/A	200 Acres	0.38	2	11	22	140	390
	cotton	1.5 lb ai/A		0.19	1	5	11	**71**	190

Table 6. Summary of Occupational Handler Risks to Endosulfan

Exposure Scenario (Scenario #)	Crop Type/Use[a]	Range of Application Rates (lb ai/A)[b]	Amount Handled per Day[c]	Baseline[f]		Additional PPE[g]		Engineering Controls[h]	
				Dermal MOE[d]	Inhalation MOE[e]	Dermal MOE[d]	Inhalation MOE[e]	Dermal MOE[d]	Inhalation MOE[e]
Mixing/Loading Wettable Powders for Airblast Application (2c)	Ornamental Trees/Shrubs	1.0 lb ai/A	40 Acres	1.4	8	40	81	540	1500
	hazelnuts	2.0 lb ai/A		0.71	4	20	41	270	730
	peaches	3.0 lb ai/A		0.47	3	13	27	270	490
Mixing/Loading Wettable Powders for Rights of Way Spray Treatment (2d)	grapes	0.005 lb ai/gal	1000 Gallons	11	65	320	650	-	-
	walnut	0.02 lb ai/gal		3	16	81	160	1100	-
Mixing/Loading Wettable Powders for Plants and Root Dip (2e)	cherry, peach, and plum	0.05 lb ai/gal	100 Gallons	11	65	320	650	-	-
Applicator Exposures									
Applying Spray with Aerial Equipment (3)	clover	0.5 lb ai/A	350 Acres	See Eng. Controls	See Eng. Controls	See Eng. Controls	See Eng. Controls	240	1200
	tobacco	2.5 lb ai/A						**48**	240
	pecans	7.5 lb ai/A						**16**	**78**
	small grains	0.75 lb ai/A	1200 Acres					**47**	230
	cotton	1.5 lb ai/A						**23**	110
Applying Sprays with a Groundboom Sprayer (4)	clover	0.5 lb ai/A	80 Acres	380	470	-	-	-	-
	tobacco	2.5 lb ai/A		75	95	95	950	210	-
	small grains	0.75 lb ai/A	200 Acres	100	130	-	-	-	-
	cotton	1.5 lb ai/A		50	63	64	630	140	-
Applying Sprays with an Airblast Sprayer (5)	ornamental trees	1.0 lb ai/A	40 Acres	15	78	24	780	280	-
	hazelnuts	2.0 lb ai/A		7.3	39	12	390	140	-
	pecans	7.5 lb ai/A		2	10	3	100	**37**	-
Applying Sprays with a Rights of Way Sprayer (6)	grapes	0.005 lb ai/gal	1000 Gallons	32	720	140	-	NA	NA
	cherries	0.04 lb ai/gal		4	90	18	900	NA	NA
Applying Dip Treatment to Roots, or Whole Plants (7)	cherry, peach, plum roots	0.05 lb ai/gal	100 gallons	No Data	No Data	ND	ND	ND	ND
Mixer/Loader/Applicator Exposure									
Mixing/Loading/Applying Liquid Formulations with a Low Pressure Handwand (8)	tobacco (drench)	0.005 lb ai/gal	40 Gallons	11	2300	2800	-	NA	NA
	tomato (greenhouse)	0.01 lb ai/gal		5	1200	1400	-	NA	NA
	cherries	0.04 lb ai/A		1.3	290	350	-	NA	NA

Table 6. Summary of Occupational Handler Risks to Endosulfan

Exposure Scenario (Scenario #)	Crop Type/Use[a]	Range of Application Rates (lb ai/A)[b]	Amount Handled per Day[c]	Baseline[f]		Additional PPE[g]		Engineering Controls[h]	
				Dermal MOE[d]	Inhalation MOE[e]	Dermal MOE[d]	Inhalation MOE[e]	Dermal MOE[d]	Inhalation MOE[e]
Mixing/Loading/Applying Wettable Powders with a Low Pressure Handwand (9)	tomato/ tobacco	0.005 lb ai/gal	40 Gallons	36	64	170	640	NA	NA
	walnut	0.02 lb ai/gal		9	16	**42**	160	NA	NA
Mixing/Loading/Applying Liquid with a High Pressure Handwand (10)	tobacco (drench)	0.005 lb ai/gal	40 Gallons	12	23	**26**	230	NA	NA
	tomato (greenhouse)	0.01 lb ai/gal		6	12	**13**	120	NA	NA
	cherries	0.04 lb ai/A		1.5	3	**3**	**29**	NA	NA
Mixing/Loading/Applying Liquid with Backpack Sprayer (11)	tobacco (drench)	0.025 lb ai/gal	40 Gallons	420	2300	-	-	NA	NA
	tomato (greenhouse)	0.01 lb ai/gal		210	1200	-	-	NA	NA
	cherries	0.04 lb ai/A		53	290	**82**	-	NA	NA
Flagger Exposures									
Flagging Aerial Spray Applications (12)	clover	0.5 lb ai/A	350 Acres	110	230	-	-	-	-
	tobacco	2.5 lb ai/A		22	46	24	460	1100	-
	pecans	7.5 lb ai/A		7	15	8	150	360	-

Footnote:

a Crops named are index crops which are chosen to represent all other crops at or near that application rate for that use. See the application rates listing in the use summary section of this document for further information on application rates used in this assessment.

b Application Rates are based on the maximum application rates listed on the endosulfan labels.

c Amount handled per day are from Science Advisory Council on Exposure's Policy # 9.

d Short- term Dermal MOE = Short- term NOAEL (mg/kg/day)/ Daily Dermal Dose (mg/kg/day).

e Short-term MOE = Short- term NOAEL (mg/kg/day)/ Daily Inhalation Dose (mg/kg/day).

f Baseline clothing: long pants, long sleeved shirt, shoes, socks.

g Additional PPE clothing: Baseline clothing plus organic vapor respirator, double layer of clothes, and chemical resistant gloves.

h Engineering controls: Enclosed mixing/loading, closed cab, truck or cockpit. Baseline level clothing. Chemical resistant gloves for airblast sprayer.

- Scenario's calculated MOE exceeds the target MOE at the previous level of mitigation. (MOE > 100)

NF = Not feasible for this scenario (no available engineering controls).ND = No data.

Bolded MOE values show a risk of concern at the highest possible level of mitigation for the corresponding scenario.

Summary of Risk Concerns for Handlers, Data Gaps, and Confidence in Exposure and Risk Estimates

Dermal and inhalation risks for handlers were assessed separately since there are different toxicological endpoints assigned to these exposures.[2] Handler exposure to endosulfan are expected to be short-term only (1 day to one month). The target MOE for the short-term exposure duration is 100.

Handler Scenarios with Risk Concerns

Dermal (Short-term)

The calculations of short-term dermal risk indicate that MOEs are **greater than or equal to 100** at **baseline** for the following scenarios:

- (4) Applying sprays with a groundboom sprayer at 0.5 lbs ai/acre and 80 acres/day and at 0.75 lb ai/acre and 200 acres/day.

- (11) Mixing/loading/applying liquids with a backpack sprayer at 0.025 and 0.01 lbs ai/gallon and 40 gallons/day.

- (12) Flagging aerial spray applications at 0.5 lbs ai/acre and 350 acres/day.

The calculations of short-term dermal risk indicate that MOEs are **greater than or equal to 100 with PPE mitigation** for the following additional scenarios:

- (1c) Mixing/loading liquids for groundboom application at 0.5 lbs ai/acre and 80 acres/day.

- (1d) Mixing/loading liquids for airblast application at l.0 and 2.0 lbs ai/acre and 40 acres/day.

- (1e) Mixing/loading liquids for rights of way sprayer application at for all assessed application rates.

- (1f) Mixing/loading liquids for plant and root dip at 0.05 lbs ai/gallon and 100 gallons/day.

- (2d) Mixing/loading wettable powders for rights of way sprayer application at for all assessed application rates.

- (2e) Mixing/loading wettable powders for plant and root dip at 0.05 lbs ai/gallon and 100 gallons/day.

- (6) Applying sprays with a rights of way sprayer at 0.005 lbs ai/acre and 1000 gallons/day.

- (8) Mixing/loading/applying liquids with a low pressure handwand sprayer for all assessed application rates.

- (9) Mixing/loading/applying wettable powders with a low pressure handwand sprayer at 0.005 lbs ai/acre and 40 gallons/day.

The calculations of short-term dermal risk indicate that MOEs are **greater than or equal to 100 with Engineering Control mitigation** for the following additional scenarios:

- (1a) Mixing/loading liquids for aerial application at 0.5 lbs ai/acre and 350 acres/day.

- (1c) Mixing/loading liquids for groundboom application at 2.5 lbs ai/acre and 80 acres/day.

- (2b) Mixing/loading wettable powders for groundboom application at 1.0 and 2.0 lbs ai/acre and 80 acres/day and 0.75 lbs ai/acre and 200 acres.

- (2c) Mixing/loading wettable powders for airblast application at l.0 and 2.0 lbs ai/acre and 40 acres/day.

- (4) Applying sprays with a groundboom sprayer at 2.5 lbs ai/acre and 80 acres/day and 1.5 lbs ai/acre and 200 acres per day.

- (5) Applying sprays with an airblast sprayer at 1.0 and 2.0 lbs ai/acre and 40 acres/day.

- (12) Flagging aerial spray applications at 2.5 and 7.5 lbs ai/acre.

Inhalation (Short-term)

The calculations of short-term inhalation risk indicate that MOEs are **greater than or equal to 100** at **baseline** for the following scenarios:

- (1c) Mixing/loading liquids for groundboom application at 0.5 lbs ai/acre and 80 acres/day.

- (1d) Mixing/loading liquids for airblast application at l.0 and 2.0 lbs ai/acre and 40 acres/day.

- (1e) Mixing/loading liquids for rights of way sprayer application for all assessed application rates.

- (1f) Mixing/loading liquids for plant and root dip at 0.05 lbs ai/gallon and 100 gallons/day.

- (4) Applying sprays with a groundboom sprayer at 0.5 lbs ai/acre and 80 acres/day and at 0.75 lbs ai/acre and 200 acres/day.

- (6) Applying sprays with a rights of way sprayer at 0.005 lbs ai/acre and 1000 gallons/day.

- (8) Mixing/loading/applying liquids with a low pressure handwand sprayer for all assessed application rates.

- (11) Mixing/loading/applying liquids with a backpack sprayer for all assessed application rates.

- (12) Flagging aerial spray applications at 0.5 lbs ai/acre and 350 acres/day.

The calculations of short-term inhalation risk indicate that MOEs are **less than 100 with PPE mitigation** for the following additional scenarios:

- (1a) Mixing/loading liquids for aerial application at 7.5 lbs ai/acre and 350 acres/day and 1.5 lbs ai/acre and 1200 acres/day.

- (2a) Mixing/loading wettable powders for aerial application for all assessed application rates.

- (2b) Mixing/loading wettable powders for groundboom application for all assessed application rates.

- (2c) Mixing/loading wettable powders for airblast application for all assessed application rates.

- (10) Mixing/loading/applying liquids with a high pressure handwand at 0.04 lbs ai/gallon and 1000 gallons/day.

The calculations of short-term inhalation risk indicate that MOEs are **less than 100 with Engineering Control mitigation** for the following additional scenarios:

- (1a) Mixing/loading liquids for aerial application at 7.5 lbs ai/acre and 350 acres/day and 1.5 lbs ai/acre and 1200 acres/day.

- (2a) Mixing/loading wettable powders for aerial application at 2.0 and 3.0 lbs ai/acre and 350 acres/day and 0.75 and 1.5 lbs ai/acre and 1200 acres/day.

- (2b) Mixing/loading wettable powders for groundboom application at 2.0 lbs ai/acre and 80 acres/day and 0.75 and 1.5 lbs ai/acre and 200 acres/day.

- (3) Applying sprays with aerial equipment at 7.5 lbs ai/acre and 350 acres/day.

Data Gaps

Data gaps exist for the following scenarios:

- (7) Applying dip treatments to trees and roots or whole plants.

- No exposure data exists for mixing/loading/applying wettable powders with a high pressure handwand and a backpack sprayer. These two scenarios are expected to have risks of concern since similar scenarios assessed in this document, mixing/loading wettable powders and mixing/loading/applying liquids with a high pressure hand wand, have risks of concern.

Data Quality and Confidence in Assessment

Several issues must be considered when interpreting the occupational exposure risk assessment. These include:

- Several generic protection factors were used to calculate handler exposures (e.g., 90 percent PF over baseline for inhalation unit exposure to account for use of an organic vapor removing respirator). These protection factors are considered conservative, but have not been completely evaluated by HED.

- Low confidence data, based on PHED grading criteria, were used to calculate the risks to handlers from the following scenarios for any body part and/or level of mitigation: Mixing/loading wettable powders, applying sprays with an airblast sprayer, applying sprays with a rights of way sprayer, mixing/loading/applying liquids and wettable powders with a low pressure handwand, mixing/loading/applying liquids with a high pressure handwand and backpack sprayer, and flagging aerial applications.

Occupational Handler Summary

Of the 21 identified occupational handler exposure scenarios, 13 of them are a risk of concern, having calculated MOEs less than the target MOE of 100, at the highest level of mitigation for **short-term dermal** exposure. For **short-term inhalation** exposure, 4 of the 21 identified occupational handler exposure scenarios are a risk of concern, having calculated MOEs less than the target MOE of 100, at the highest level of mitigation. Three scenarios lack data to assess their risk.

Data is needed to assess the following occupational handler scenarios: applying dip treatments to trees and roots or whole plants and mixing/loading/applying wettable powders with a backpack sprayer and a high pressure handwand.

Occupational Postapplication Exposures and Risks

Postapplication Exposures and Assumptions

EPA has determined that there are potential short- and intermediate-term postapplication exposures to individuals entering treated fields. Current endosulfan labels restricted entry interval (REI) requirement is 24 hour REI with the following early entry PPE required: coveralls, waterproof gloves, shoes, socks and chemical resistant headgear for overhead exposures.

For the purpose of conducting this assessment, crops were grouped in order to assign the most representative dislodgeable foliar residue (DFR) data to the crops. The crop groups listed below were chosen because appropriate residue data were available (see description of postapplication DFR study below: MRID 444031-02). The crop groups and corresponding surrogate residue data sources are as follows:

- **Tree Crops**: DFR data for peaches were used, based on a study using an application rate of 3 lb ai/acre. This application rate is consistent with the application rates for most fruit and nut trees. For the crops where the application rates were not 3 lbs ai/acre, the DFR data were adjusted (linear) to the appropriate application rate for the individual crops.

- **Grape** Harvesting, Girdling and Irrigating: This scenario is based on DFR data for grapes using an application rate of 1.5 lbs ai/acre. This is the labeled application rate for grapes.

- **Field Crops:** DFR data for melons were used and were assumed to be representative of exposure from postapplication activities associated with all the remaining crops registered for endosulfan except for grapes and tree crops. The DFR data were based on an application rate of 1 lb ai/acre. However, most of the labeled application rates for these crops range from 0.25 to 3 lb ai/acre. Thus, the DFR data were adjusted (linear) to the appropriate application rate for the individual crops.

Chemical-specific DFR Data

A DFR study was conducted for endosulfan and its metabolites, beta-endosulfan and endosulfan sulfate. The study evaluated dislodgeable residue dissipation for endosulfan applied to peaches, grapes, and melons (MRID No. 444031-02)[14]. In summary, the dislodgeable foliar residue study completed in support of the regulatory requirements for endosulfan did not completely meet the criteria contained in Subdivision K of the Pesticide Assessment Guidelines. This conclusion is based on the following issue: the DFR study was performed in only one geographical area. Series 875, Occupational and Residential Test Guidelines (an update to Subdivision K), recommend that, "In general, DFR samples should be collected from at least three geographically distinct locations per formulation type;" While the Endosulfan Task Force contends that California is the worst case climate for the least amount of residue dissipation, further DFR studies may need to be conducted in the areas where there is the highest use of endosulfan. Other issues were identified in HED's review of the DFR study[14], but these were addressed in a supplemental report submitted by the Endosulfan Task Force.[15]

Despite the uncertainty listed above, HED recommended that the data from this DFR study be used in assessing the appropriate post-application exposure from agricultural activities using endosulfan. The study is appropriate for regulatory use in assessing postapplication residues on fruit trees and low growing fruits crops. The DFR data from this study were used in assessing postapplication risks to endosulfan.

Peaches - Endosulfan (Phaser 3EC and Phaser 50WP) was applied to plots of mature fruit at a site located in California using an "Air-O-Fan" airblast sprayer which operated at 150 PSI and sprayed approximately 400 gallons per acre. The test substance was applied at a rate of 3 lb ai/acre. A single application was made. (This may underestimate exposures following repeated applications as indicated on the label.) Foliage samples were collected at days 0 1, 3, 5, 7, 10, 14, 17, 21, 24, and 28 postapplication. Each sample consisted of 40 leaf discs that were 5 cm^2. Leaf samples were collected in glass jars and transported to the laboratory on blue ice. The samples

were dislodged the same day as collected and analyzed for levels of alpha-endosulfan, beta-endosulfan, and endosulfan sulfate. Laboratory recovery samples were within the acceptable range. The residue data for peaches are shown in Table 8.

For the purposes of this assessment, a regression analysis was conducted using the natural log-transformed DFR data from this study. Average DFR data from each of the 4 trials done for both formulations were used in the regression analysis. To predict residue levels on peaches, the following equation was used:

$y = mx + b$ where:

x	=	days postapplication;
m	=	slope of the regression line;
b	=	constant; and
y	=	residue on day x.

For Phaser 3EC applied to peaches, m is -0.09131 and b is -1.91431. The R^2 value for these data is 0.71. For Phaser 50WP applied to peaches, m is -0.09728, b is -0.55653, and R^2 is 0.93. The predicted DFRs on days 1 through 41 are shown in Table 10 for Phaser 50WP. The predicted DFRs on days 1 through 53 are shown in Table 11 for Phaser 3EC. This study used an application rate of 3 lbs ai/acre and a single application. This is consistent with the labeled application rates for peaches and other fruit and nut trees. For the crops where the application rates were not 3 lbs ai/acre, the DFR data were adjusted (linear) to the appropriate application rate for the individual crops.

Grapes - Endosulfan (Phaser 3EC and Phaser 50WP) was applied to grapes at a location in California. The pesticide was applied by an Allis Chalmers G III U-Boom Grape Sprayer, at a rate of 1.5 lbs ai/acre. Two applications were made. Foliage samples were collected from the experimental plots at 0, 1, 3, 5, and 7 days after the first application and at days 0, 1, 3, 5, 7, 10, 14, 17, 21, 24, and 28 days after the second application. Foliage samples consisted of 40 leaf discs that were 5 cm^2. Leaf samples were collected in glass jars and transported to the laboratory on blue ice. The samples were dislodged the same day as collected and analyzed for levels of alpha-endosulfan, beta-endosulfan, and endosulfan sulfate. Laboratory recovery samples were within the acceptable range. The residue data for grapes are shown in Table 8.

For the purposes of this assessment, a regression analysis was conducted using the natural log-transformed DFR data after the second application from this study to predict residue levels, as shown above. Average DFR data from each of the 4 trials done for both formulations were used in the regression analysis. For Phaser 50WP on grapes, m is -0.07169, b is -0.17214, and R^2 is 0.74. The predicted DFRs on days 1 through 66 are shown in Table 10 for Phaser 50WP. For Phaser 3EC on grapes, m is -0.10004 and b is -1.66886, after the second application. The R^2 value for these data is 0.52. Since the R^2 is so low, all of the replicates were analyzed in a regression analysis for the Phaser 3EC use on grapes. This analysis yielded a higher R^2 of 0.65 with a m of -0.1268 and a b of-1.583. The actual residue data for all four replicates for the use of

the Phaser 3EC on grapes are presented in Table 9. The predicted DFRs on days 1 to 67 from the use of the 4 replicates of actual residues are shown in Table 11 for Phaser 3EC. This study used an application rate of 1.5 lbs ai/acre and two applications. This is consistent with the labeled application rate for grapes.

Melons - Endosulfan (Phaser 3EC and Phaser 50WP) was applied to melons at a site in California. Pesticide was applied by an Allis Chalmers GII sprayer (appears to be similar to a groundboom sprayer) at a rate of 1 lb ai/acre. Two applications were made. The melons were immature at the time of both applications. Foliage samples were collected by leaf punch at 0, 1, 3, 5, and 7 days after the first application and at days 0, 1, 3, 5, 7, 10, 14, 17, 21, 24, and 28 days after the second application. Foliage samples consisted of 40 leaf discs that were 5 cm^2. Leaf samples were collected in glass jars and transported to the laboratory on blue ice. The samples were dislodged the same day as collected and analyzed for levels of alpha-endosulfan, beta-endosulfan, and endosulfan sulfate. Laboratory recovery samples were within the acceptable range. However, field recovery samples were not analyzed and no storage stability study was conducted. The residue data for melons are shown in Table 8.

For the purposes of this assessment, a regression analysis was conducted using the natural log-transformed DFR data after the second application from this study to predict residue levels, as shown above. Average DFR data from each of the 4 trials done for both formulations were used in the regression analysis. For melons, m is -0.12341 and b is -1.15627 for Phaser 3EC. The R^2 value for these data is 0.76. For Phaser 50WP on melons, m is -0.13955, b is -0.35023, and R^2 is 0.88. The estimated DFRs on days 1 through 38 are shown in Table 10 for Phaser 50WP. The estimated DFRs on days 1 through 48 are shown in Table 11 for Phaser 3EC. This study used an application rate of 1 lbs ai/acre and two applications. However, most of the labeled application rates for these crops range from 0.25 to 3 lb ai/acre. Thus, the DFR data were adjusted (linear) to the appropriate application rate for the individual crops.

It should be noted that another DFR study (MRID 403039-01) was conducted for endosulfan.[16] This study examined DFR residues on apples, apricots, processing tomatoes, and cherry tomatoes. The study was unacceptable for the following reasons:

- The field recovery data for apples and processing tomatoes were unacceptably low and field recovery data for apricots and cherry tomatoes were variable;
- The lab recovery data for all crops were highly variable;
- Storage stability data were not provided; apple, apricot, and processing tomato samples were stored for approximately 4 months and cherry tomato samples were stored for an unspecified period of time prior to analysis; and
- Meteorological data were incomplete.

Therefore, this study is unacceptable and was not used in estimating postapplication exposures in this document. All postapplication exposure estimates were based on MRID No. 444031-02. Table 7 compares the half lives of the two endosulfan DFR studies. The half lives from the unacceptable study were similar to or higher than the half lives from the study used to determine post-application exposure in this assessment. This demonstrates that the DFR data from the unacceptable study would result in restricted entry interval calculations similar to or even longer than the ones calculated in this assessment.

Table 7. Comparison of DFR Data Half Lives for Wettable Powder Formulation.

DFR Study Used in Assessment 444031-02		Unacceptable Study 403039-01	
Crop	**Half Life (days)[a]**	**Crop**	**Half Life (days)[a]**
Grapes	9.7	Apples	15.2
Melons	5.0	Apricots	11
Peaches	7.1	Processing Tomatoes	12.8
		Cherry Tomatoes	5

a Half life (days) = -ln (2)/m where m = slope of predicted residues from the regression analysis.

Exposure and Risk Calculations

The DFR data was adjusted for other application rates using the following equation:

$$Adjusted\ DFR\ (\ g/cm^2) = \frac{Study\ DFR\ (\ g/cm^2)\ x\ crop\ application\ rate\ (lbsai/A)}{study\ application\ rate\ (lbsai/A)}$$

Short/intermediate-term doses and MOEs were calculated as follows:

$$ADD = [DFR \times Tc \times ET \times mg/1000\ \mu g] \div BW$$

where:

ADD = average daily dose (mg/kg/day);
DFR = dislodgeable foliar residue (g/cm^2);
Tc = transfer coefficient (cm^2/hr);
ET = exposure time (8 hours/day); and
BW = body weight (70 kg).

and

$$MOE = NOAEL/ADD$$

The crops were grouped according to similar application rates, transfer coefficients, and DFR data used. The assumptions used for both short and intermediate term post application exposures are as follows:

Assumptions

- The maximum transfer coefficients for each crop were used to determine the highest possible post-application exposure and restricted entry intervals. Scouting and irrigation transfer coefficients were also used to determine possible exemptions to the restricted entry intervals calculated for the highest post-application exposures.

- The transfer coefficients used in this assessment are from the Agricultural Re-entry Task Force (ARTF) database. An interim transfer coefficient policy was developed by HED's Science Advisory Council for Exposure using the ARTF database (policy # 3.1). It is the intention of HED's Science Advisory Council for Exposure that this policy will be periodically updated to incorporate additional information about agricultural practices in crops and new data on transfer coefficients. Much of this information will originate from exposure studies currently being conducted by the ARTF, from the further analysis of studies already submitted to the Agency, and from the studies in the published scientific literature.[17]

- Exposure time is assumed to be 8 hours per day. This represents a typical work day.

- The average body weight of 70 kg is used.

- Postapplication workers are assumed to be exposed continuously to endosulfan, particularly when application is repeated every seven days for two to three applications. Therefore, short- and intermediate-term risks are assessed.

Table 8. Actual Average Dislodgeable Foliar Residues of Endosulfan in Melons, Peaches, and Grapes.

Application	Sample Interval (DAT)[b]	DFR Residues (µg/cm^2)[a]					
		Melon		Peach		Grapes	
		3EC	50WP	3EC	50WP	3EC	50WP
1	0	0.70	1.77	NA	NA	0.61	1.51
	1	0.21	0.72	NA	NA	0.26	0.90
	3	0.05	0.22	NA	NA	0.08	0.61
	5	0.05	0.19	NA	NA	0.06	0.39
	7	0.04	0.11	NA	NA	0.04	0.29
2	0	1.23	1.00	0.46	1.02	0.71	1.32
	1	0.54	1.14	0.16	0.55	0.31	1.36
	3	0.15	0.53	0.09	0.43	0.11	0.51
	5	0.09	0.32	0.07	0.30	0.09	0.74
	7	0.06	0.18	0.04	0.22	0.03	0.28
	10	0.05	0.12	0.03	0.16	0.02	0.20
	14	0.05	0.07	0.03	0.11	0.04	0.24
	17	0.03	0.04	0.03	0.10	0.05	0.30
	21	0.02	0.02	0.05	0.09	0.02	0.20
	24	0.02	0.04	0.02	0.07	0.04	0.19
	28	0.02	0.03	0.01	0.04	LOQ	0.13

Footnotes:

LOQ- DFR residue is below limit of quantification (0.01 g/cm^2) .

NA- not applicable. Peaches have only one application of pesticide.

[a] DFR residues from crops are obtained from application of either two labeled products (Phaser® EC or Phaser® WP), and table entries are averages of triplicate samples taken at each sample interval.

[b] DAT = days after treatment.

Table 9. Actual Dislodgeable Foliar Residues of Endosulfan in Grapes Using the EC Formulation.

Day after treatment	Replicate 1 (g/cm^2)	Replicate 2 (g/cm^2)	Replicate 3 (g/cm^2)	Replicate 4 (g/cm^2)
0	0.810	0.790	0.620	0.630
1	0.260	0.380	0.280	0.330
3	0.100	0.110	0.100	0.120
5	0.110	0.120	0.080	0.050
7	0.020	0.040	0.030	0.020
10	0.020	0.030	0.020	0.010
14	0.010	0.040	0.100	0.020
17	0.030	0.080	0.050	0.030
21	0.010	0.020	0.010	0.050
24	0.010	0.020	0.005[a]	0.080
28	0.005[a]	0.005[a]	0.005[a]	0.005[a]

Footnote:

a Less than LOQ of 0.01 g/cm^2 so half of the LOQ was used.

Table 10. Predicted DFR Levels Based on Measured DFRs for Phaser 50WP used on Peaches, Grapes, and Melons

Sample Interval (DAT)[a]	DFR g/cm^2			Sample Interval (DAT)[a]	DFR g/cm^2		
	Grapes	Peaches	Melons		Grapes	Peaches	Melons
0	0.84	0.57	0.70	34	0.074	0.021	0.0065
1	0.78	0.52	0.65	35	0.068	0.019	0.0056
2	0.73	0.47	0.56	36	0.064	0.017	0.0046
3	0.68	0.43	0.49	37	0.059	0.016	0.004
4	0.63	0.39	0.43	38	0.055	0.014	0.0035
5	0.59	0.35	0.37	39	0.051	0.013	
6	0.55	0.32	0.32	40	0.048	0.012	
7	0.51	0.29	0.28	41	0.045	0.011	
8	0.47	0.26	0.24	42	0.041		
9	0.44	0.24	0.21	43	0.039		
10	0.41	0.22	0.18	44	0.036		
11	0.38	0.20	0.16	45	0.033		
12	0.36	0.18	0.14	46	0.031		
13	0.33	0.16	0.12	47	0.029		
14	0.31	0.15	0.11	48	0.027		
15	0.29	0.13	0.092	49	0.025		
16	0.27	0.12	0.08	50	0.023		
17	0.25	0.11	0.069	51	0.022		
18	0.23	0.099	0.06	52	0.020		
19	0.22	0.090	0.052	53	0.019		
20	0.20	0.082	0.046	54	0.018		
21	0.19	0.074	0.04	55	0.016		
22	0.17	0.067	0.034	56	0.015		
23	0.16	0.061	0.03	57	0.014		
24	0.15	0.056	0.026	58	0.013		
25	0.14	0.050	0.023	59	0.012		
26	0.13	0.046	0.02	60	0.011		
27	0.12	0.041	0.017	61	0.011		
28	0.11	0.038	0.015	62	0.0099		
29	0.11	0.034	0.013	63	0.0092		
30	0.10	0.031	0.011	64	0.0086		
31	0.091	0.028	0.0098	65	0.0080		
32	0.085	0.025	0.0085	66	0.0074		
33	0.079	0.023	0.0074				

Footnote:

[a] DAT = days after treatment.

Table 11. Predicted DFR Levels Based on Measured DFRs for Phaser 3 EC used on Peaches, Grapes, and Melons

Sample Interval (DAT)[a]	DFR g/cm²			Sample Interval (DAT)[a]	DFR g/cm²		
	Grapes	Peaches	Melons		Grapes	Peaches	Melons
0	0.20	0.15	0.31	34	0.0028	0.0066	0.0047
1	0.18	0.13	0.28	35	0.0024	0.0060	0.0042
2	0.16	0.12	0.25	36	0.0021	0.0055	0.0037
3	0.14	0.11	0.22	37	0.0019	0.0050	0.0033
4	0.12	0.10	0.19	38	0.0017	0.0046	0.0029
5	0.11	0.093	0.17	39	0.0015	0.0042	0.0026
6	0.096	0.085	0.15	40	0.0013	0.0038	0.0023
7	0.085	0.078	0.13	41	0.0011	0.0035	0.0020
8	0.074	0.071	0.12	42	0.0010	0.0032	0.0018
9	0.066	0.065	0.010	43	0.00088	0.0029	0.0016
10	0.058	0.059	0.092	44	0.00078	0.0027	0.0014
11	0.051	0.054	0.081	45	0.00068	0.0024	0.0012
12	0.045	0.049	0.072	46	0.00060	0.0022	0.0011
13	0.040	0.045	0.063	47	0.00053	0.0020	0.00095
14	0.035	0.041	0.056	48	0.00047	0.0018	0.00084
15	0.031	0.037	0.049	49	0.00041	0.0017	
16	0.027	0.034	0.044	50	0.00036	0.0015	
17	0.024	0.031	0.039	51	0.00032	0.0014	
18	0.021	0.028	0.034	52	0.00028	0.0013	
19	0.018	0.026	0.030	53	0.00025	0.0012	
20	0.016	0.024	0.027	54	0.00022	0.0011	
21	0.014	0.022	0.024	55	0.00019	0.00097	
22	0.013	0.020	0.021	56	0.00017	0.00089	
23	0.011	0.018	0.018	57	0.00015	0.00081	
24	0.0098	0.016	0.016	58	0.00013	0.00074	
25	0.0086	0.015	0.014	59	0.00012	0.00067	
26	0.0076	0.014	0.013	60	0.00010	0.00062	
27	0.0067	0.013	0.011	61	0.000091	0.00056	
28	0.0059	0.011	0.0099	62	0.000080	0.00051	
29	0.0052	0.010	0.0088	63	0.000070	0.00047	
30	0.0046	0.0095	0.0078	64	0.000062	0.00043	
31	0.0040	0.0087	0.0069	65	0.000055	0.00039	
32	0.0036	0.0079	0.0061	66	0.000048	0.00036	
33	0.0031	0.0072	0.0054	67	0.000042	0.00032	

Footnote:

[a] DAT = days after treatment.

Short-term Post-application Exposures and Risks

A dose and a MOE are determined from the declining predicted DFR values until the target MOE of 100 is reached for every crop for both formulations. These data are summarized in Table 12 for short-term exposures. The NOAEL used in the short-term assessment is 3.0 mg/kg/day and the target MOE is 100 for short term exposure duration.

Table 12. Endosulfan Short-term Occupational Postapplication Assessment.

Crop[a]	Maximum Label Application Rate (lbs ai/acre)[d]		Transfer Coefficient[e] (cm^2/hr)	Activity[f]	DFR Surrogate Data Source[g]	DAT[h]	DFR[i] (g/cm^2)		MOE[j]	
	WP[b]	EC[c]					WP[b]	EC[c]	WP[b]	EC[c]
Table Grapes / Raisins	1.5	1.5	10,000	Cane turning and tying, and girdling.	grapes	0	0.84	0.20	3	14
						17	0.25	0.023	10	110
						49	0.029	NA	100	NA
Juice Grapes	1.5	1.5	5,000	Tying, training, hand harvesting, hand pruning, and thinning.	grapes	0	0.84	0.20	6	25
						11	0.38	0.051	14	100
						39	0.051	NA	110	NA
Grapes, Table / Raisin and Juice	1.5	1.5	1,000	Scouting and irrigating	grapes	0	0.84	0.20	31	130
						17	0.25	NA	100	NA
Apple, Apricot, Cherry, Nectarines, Peach, Pear, Plum, Prune, and Christmas Trees.	3	3	8,000	Thinning, staking, topping, training, and hand harvesting.	peach	0	0.57	0.15	6	21
						17	0.11	0.03	27	110
						30	0.031	NA	110	NA
Ornamental Trees / Shrubs including Evergreen Trees and Non-bearing Citrus Trees	3	3	3,000	Hand pruning and seed cone harvesting.	peach	0	0.57	0.15	15	59
						6	0.32	0.085	27	100
						20	0.082	NA	110	NA
Apple, Apricot, Cherry, Nectarines, Peach, Pear, Plum, Prune, and Ornamental Trees / Shrubs including Evergreen Trees, Non-bearing Citrus Trees and Christmas Trees.	3	3	1,000	Irrigating and scouting	peach	0	0.57	0.15	46	180
						8	0.26	NA	100	NA
Macadamia Nuts and Pecans	NA	7.5	2,500	Hand harvesting, pruning, and thinning.	peach	0	NA	0.37	NA	27
						14	NA	0.03	NA	100
			500	Irrigating and scouting	peach	0	NA	0.37	NA	140
Hazelnut, Almonds and Walnut	2	2.5	2,500	Hand harvesting and pruning.	peach	0	0.38	0.12	27	88
						2	0.32	0.10	33	100
						14	0.10	NA	110	NA
			500	Irrigating and scouting	peach	0	0.38	0.12	140	440
Blueberries, Kohlrabi, Broccoli, and Cabbage.	2	2	5,000	Hand harvesting, pruning, thinning, and irrigating.	melon	0	1.4	0.63	4	8
						20	0.09	0.03	61	100
						24	0.05	NA	110	NA

Table 12. Endosulfan Short-term Occupational Postapplication Assessment.

Crop[a]	Maximum Label Application Rate (lbs ai/acre)[d]		Transfer Coefficient[e] (cm^2/hr)	Activity[f]	DFR Surrogate Data Source[g]	DAT[h]	DFR[i] (g/cm^2)		MOE[j]	
	WP[b]	EC[c]					WP[b]	EC[c]	WP[b]	EC[c]
Kohlrabi, Broccoli, and Cabbage.	2	2	4,000	Irrigating and scouting	melon	0	1.4	0.63	5	10
						19	0.099	0.60	67	110
						22	0.065	NA	100	NA
Blueberries	2	2	1,000	Irrigating and scouting	melon	0	1.4	0.63	19	42
						8	0.46	0.23	57	120
						12	0.26	NA	100	NA
Brussel Sprouts and Cauliflower	1	1	5,000	Topping, irrigating, hand harvesting, and tying.	melon	0	0.7	0.31	8	17
						15	0.09	0.05	60	110
						19	0.05	NA	100	NA
			4,000	Irrigating and scouting	melon	0	0.70	0.31	9	21
						13	0.11	0.063	60	100
						17	0.066	NA	100	NA
Corn	1.5	1.5	17,000	Detasseling	melon	0	1.1	0.47	1	3
						28	0.02	0.02	73	100
						31	0.01	NA	110	NA
			1,000	Irrigating and scouting	melon	0	1.1	0.47	23	56
						5	0.53	0.25	49	100
						10	0.26	NA	100	NA
Cucumber, Melons, Pumpkin, Squash, Beans, Peas, Celery, Lettuce, Spinach, and Carrots.	1	1	2,500	Hand harvesting, pruning, thinning, turning, and leaf pulling	melon	0	0.7	0.31	15	34
						9	0.2	0.1	53	100
						14	0.1	NA	100	NA
Alfalfa, Barley, Clover, Oats, Rye, Wheat, White Potatoes, Cucumber, Melons, Pumpkin, Squash, Beans, Peas, Celery, Lettuce, and Spinach.	1	1	1,500	Irrigating and scouting	melon	0	0.7	0.31	25	57
						5	0.35	0.17	50	100
						10	0.17	NA	100	NA
Carrots	1	1	300	Irrigating and scouting	melon	0	0.70	0.31	130	270

Table 12. Endosulfan Short-term Occupational Postapplication Assessment.

Crop[a]	Maximum Label Application Rate (lbs ai/acre)[d]		Transfer Coefficient[e] (cm^2/hr)	Activity[f]	DFR Surrogate Data Source[g]	DAT[h]	DFR[i] (g/cm^2)		MOE[j]	
	WP[b]	EC[c]					WP[b]	EC[c]	WP[b]	EC[c]
Pepper, Eggplant, and Tomato	1	1	1,000	Hand harvesting, staking, tying, pruning, thinning, and training.	melon	0	0.7	0.31	38	86
						2	0.53	0.25	49	100
						8	0.23	NA	120	NA
			700	Irrigating and scouting	melon	0	0.70	031	54	120
						5	0.5	NA	110	NA
Pineapple	2	2	1,000	Hand harvesting	melon	0	1.4	063	19	42
						8	0.46	0.23	57	120
						12	0.26	NA	100	NA
			500	Irrigating and scouting	melon	0	1.4	0.63	38	83
						2	1.1	0.49	48	110
						7	0.53	NA	100	NA
Strawberry	2	2.5	1,500	Hand harvesting, pinching, pruning, and training.	melon	0	1.4	0.79	13	21
						13	0.23	0.16	77	110
						15	0.17	NA	100	NA
			400	Irrigating and scouting	melon	0	1.4	0.79	47	83
						2	1.1	0.61	60	110
						6	0.61	NA	110	NA
Cotton, Collard Greens, Kale, Mustard Greens, Sweet Potato, Radish, Rutabaga, and Turnip.	2	2	2,500	Hand harvesting, pruning, and thinning.	melon	0	1.4	0.63	8	17
						15	0.17	0.1	61	110
						18	0.1	NA	110	NA
Cotton, Collard Greens, Kale, Mustard Greens, and Sweet Potato.	2	2	1,500	Irrigating and scouting.	melon	0	1.4	0.63	13	27
						11	0.30	0.16	59	110
						15	0.17	NA	100	NA

Table 12. Endosulfan Short-term Occupational Postapplication Assessment.

Crop[a]	Maximum Label Application Rate (lbs ai/acre)[d]		Transfer Coefficient[e] (cm^2/hr)	Activity[f]	DFR Surrogate Data Source[g]	DAT[h]	DFR[i] (g/cm^2)		MOE[j]	
	WP[b]	EC[c]					WP[b]	EC[c]	WP[b]	EC[c]
Radish, Rutabaga, and Turnip.	2	2	300	Irrigating and scouting.	melon	0	1.4	0.63	63	140
						4	0.81	NA	110	NA
Tobacco	1.5	3	2,000	Hand harvesting, pruning, striping, thinning, topping, and hand weeding.	melon	0	1.1	0.94	12	14
						15	0.13	0.15	100	88
						16	NA	0.13	NA	100
			1,300	Irrigating and scouting	melon	0	1.1	0.94	19	21
						12	0.20	0.20	100	97
						13	NA	0.19	NA	110

Footnotes:

NA = Not applicable (MOE > 100 on a previous day or formulation use does not exist for the crop).

a Crops were grouped according to similar application rates, transfer coefficients, and surrogate DFR data sources.

b WP = wettable powder formulation

c EC = emulsifiable concentrate formulation

d maximum application rates as stated on current endosulfan labels.

e Transfer Coefficients from Science Advisory Council on Exposure Policy 3.1.[17]

f Activities from Science Advisory Council on Exposure Policy 3.1.[17] Every activity listed may not occur for every crop in the group.

g The appropriate DFR surrogate data source for each crop was determined by the similarity in crop types and quality of the data.

h DAT is "days after treatment" (0 days = 12 hours after application).

i Predicted DFR values were obtained through study data of endosulfan residues on the foliage of melons, peach trees and grapes in CA (MRID 444031-02). DFR values were adjusted proportionately to reflect different application rates. The adjusted DFR = (study DFR X crop application rate)/study application rate.

j MOE = NOAEL (mg/kg/day) / Dermal dose (mg/kg/day). Target MOE = 100.

Intermediate-term Post-application Exposures and Risks

Intermediate-term post application exposure is expected because endosulfan is registered for a large number of crops and postapplication workers maybe exposed continuously to endosulfan, particularly when application is repeated every seven days for two to three applications. For short-term post application exposure, the worker is assumed to be exposed to the residue level that occurs on the day the calculated MOE reaches the target MOE from one day to possibly the entire exposure duration, without factoring declining residues over time (30 days). It is possible for a worker to re-enter multiple fields, encountering a high residue level in each field. For example, the target MOE was reached on day 8 for the wettable powder formulation on peppers. Therefore, a worker could enter the field on day 8 and the worst case exposure would be that the worker is exposed to day 8 residues for up to 30 days. This exposure would be not be considered to have a risk of concern, since the target MOE was reached on day 8.

Since the intermediate-term exposure duration is 30 days to several months, it would be improbable that a worker would contact the same residue level for the entire exposure duration. Instead, an average of 30 days of predicted residues is determined from the day the short-term duration does not have a risk of concern. The probable worst case scenario for intermediate-term would be that a worker would be exposed to an average of the residues that are possible during the 30 day decline in the short-term exposure duration. If this residue value does not yield a target MOE of 300 for intermediate-term, then the average residue value is shifted one day, until the target MOE is reached. Then the day when there is not risk of concern for the intermediate-term would be the first day of the average residue period. For example, since the worker in the previous example could re-enter the field on day 8 for the short-term duration, then the residues from day 8 to day 38 would be averaged. This value must result in a target MOE at or above 300, for the intermediate-term duration to not be of concern on the same day as the short-term duration (day 8). If this average residue value results in an MOE of less than the target MOE, than the decline period is shifted to 9 to 39 days. This is done until the target MOE is reached for the average residue value. If it was reached for the 9 to 39 day period, then 9 days would be the day that the intermediate-term duration would not have a risk of concern.

A dose and MOE intermediate-term calculations are summarized in Table 13 for intermediate-term exposures. The NOAEL used in the intermediate-term assessment is 3.0 mg/kg/day and the target MOE is 300.

Table 13. Endosulfan Intermediate-term Occupational Postapplication Assessment.

Crop[a]	Maximum Label Application Rate (lbs ai/acre)[b]		Transfer Coefficient[c] (cm^2/hr)	Activity[d]	DFR Surrogate Data Source[e]	Formulation[f]	Decline Period[g]	Average DFR[i] (g/cm^2)[h]	MOE[i]
Table Grapes / Raisins	1.5	1.5	10,000	Cane turning and tying, and girdling	grapes	WP	49 to 79	0.010	250
							50 to 80	0.0097	270
							51 to 81	0.0090	290
							52 to 82	0.0084	310
						EC	17 to 47	0.0063	520
Juice Grapes	1.5	1.5	5,000	Tying, training, hand harvesting, hand pruning, and thinning.	grapes	WP	39 to 69	0.021	250
							40 to 70	0.020	260
							41 to 71	0.019	280
							42 to 72	0.017	310
						EC	11 to 41	0.013	390
Grapes, Table / Raisin and Juice	1.5	1.5	1,000	Scouting and irrigating	grapes	WP	17 to 47	0.11	250
							18 to 48	0.10	270
							19 to 49	0.09	290
							20 to 40	0.08	320
						EC	0 to 30	0.055	480
Apple, Apricot, Cherry, Nectarines, Peach, Pear, Plum, Prune, and Christmas Trees.	3	3	8,000	Thinning, staking, topping, training, and hand harvesting.	peach	WP	30 to 60	0.010	320
						EC	17 to 47	0.011	300
Ornamental Trees / Shrubs including Evergreen Trees and Non-bearing Citrus Trees.	3	3	3,000	Hand pruning and seed cone harvesting	peach	WP	20 to 50	0.037	320
						EC	6 to 36	0.030	300
Apple, Apricot, Cherry, Nectarines, Peach, Pear, Plum, Prune, and Ornamental Trees / Shrubs including Evergreen Trees, Christmas Trees, and Non-bearing Citrus Trees.	3	3	1,000	Scouting and irrigating	peach	WP	8 to 38	0.087	300
						EC	0 to 30	0.051	510
Macadamia nuts and Pecans	NA	7.5	2,500	Hand harvesting, pruning, and thinning	peach	EC	14 to 44	0.048	220
							15 to 45	0.044	240
							16 to 46	0.040	260
							17 to 47	0.036	290
							18 to 48	0.033	320
			500	Irrigating and scouting	peach	EC	0 to 30	0.13	410

Table 13. Endosulfan Intermediate-term Occupational Postapplication Assessment.

Crop[a]	Maximum Label Application Rate (lbs ai/acre)[b]		Transfer Coefficient[c] (cm^2/hr)	Activity[d]	DFR Surrogate Data Source[e]	Formulation[f]	Decline Period[g]	Average DFR[i] (g/cm^2)[h]	MOE[i]
Hazelnut, Almonds and Walnut	2	2.5	2,500	Hand harvesting and pruning	peach	WP	14 to 44	0.033	320
						EC	2 to 32	0.054	190
							3 to 33	0.049	210
							4 to 34	0.045	230
							5 to 35	0.041	260
							6 to 36	0.038	280
							7 to 37	0.034	310
			500	Irrigating and scouting	peach	EC	0 to 30	0.040	1200
Blueberries, Kohlrabi, Broccoli, and Cabbage.	2	2	5,000	Hand harvesting, pruning, thinning, and irrigating.	melon	WP	24 to 54	0.012	430
						EC	20 to 50	0.015	340
Kohlrabi, Broccoli, and Cabbage.	2	2	4,000	Irrigating and scouting.	melon	WP	22 to 52	0.016	410
						EC	19 to 49	0.017	390
Blueberries	2	2	1,000	Irrigating and scouting.	melon	WP	12 to 42	0.064	410
						EC	8 to 38	0.064	410
Brussel Sprouts and Cauliflower	1	1	5,000	Topping, irrigating, Hand harvesting, and tying.	melon	WP	19 to 49	0.012	430
						EC	15 to 45	0.013	390
			4,000	Irrigating and scouting.	melon	WP	17 to 47	0.016	410
						EC	13 to 43	0.017	380
Corn	1.5	1.5	17,000	Detasseling	melon	WP	31 to 61	0.0034	450
						EC	28 to 58	0.0040	380
			1,000	Irrigating and scouting.	melon	WP	10 to 40	0.064	410
						EC	5 to 35	0.069	380
Cucumber, Melons, Pumpkin, Squash, Beans, Peas, Celery, Lettuce, Spinach, and Carrots.	1	1	2,500	Hand harvesting, pruning, thinning, turning, and leaf pulling	melon	WP	14 to 44	0.024	430
						EC	9 to 39	0.028	370
Alfalfa, Barley, Clover, Oats, Rye, Wheat, White Potatoes, Cucumber, Melons, Pumpkin, Squash, Beans, Peas, Celery, Lettuce, and Spinach.	1	1	1,500	Irrigating and scouting	melon	WP	10 to 40	0.043	410
						EC	5 to 35	0.046	380
Carrots	1	1	300	Irrigating and scouting	melon	WP	0 to 30	0.17	510
						EC	0 to 30	0.08	1000

Table 13. Endosulfan Intermediate-term Occupational Postapplication Assessment.

Crop[a]	Maximum Label Application Rate (lbs ai/acre)[b]		Transfer Coefficient[c] (cm^2/hr)	Activity[d]	DFR Surrogate Data Source[e]	Formulation[f]	Decline Period[g]	Average DFR[i] (g/cm^2)[h]	MOE[i]
Pepper, Eggplant, and Tomato	1	1	1,000	Hand harvesting, staking, tying, pruning, thinning, and training.	melon	WP	8 to 38	0.056	470
						EC	2 to 32	0.067	400
			700	Irrigating and scouting	melon	WP	5 to 35	0.086	440
						EC	0 to 30	0.068	440
Pineapple	2	2	1,000	Hand harvesting	melon	WP	12 to 42	0.065	410
						EC	8 to 38	0.0073	410
			500	Irrigating and scouting	melon	WP	7 to 37	0.13	410
						EC	2 to 32	0.14	410
Strawberry	2	2.5	1,500	Hand harvesting, pinching, pruning, and training.	melon	WP	15 to 45	0.042	410
						EC	13 to 43	0.043	410
			400	Irrigating and scouting	melon	WP	6 to 36	0.15	440
						EC	2 to 32	0.17	400
Cotton, Collard Greens, Kale, Mustard Greens, Sweet Potato, Radish, Rutabaga, and Turnip.	2	2	2,500	Hand harvesting, pruning, and thinning.	melon	WP	19 to 49	0.024	430
						EC	15 to 45	0.027	390
Cotton, Collard Greens, Kale, Mustard Greens, and Sweet Potato.	2	2	1,500	Irrigating and scouting	melon	WP	15 to 45	0.042	410
						EC	11 to 41	0.044	400
Radish, Rutabaga, and Turnip.	2	2	300	Irrigating and scouting	melon	WP	4 to 44	0.20	440
						EC	0 to 30	0.17	500
Tobacco	1.5	3	2,000	Hand harvesting, pruning, striping, thinning, topping, and hand weeding	melon	WP	15 to 45	0.032	410
						EC	16 to 46	0.036	370
			1,300	Irrigating and scouting	melon	WP	12 to 42	0.048	420
						EC	13 to 43	0.052	400

Footnotes:

NA = Not applicable (formulation use does not exist for the crop).

a Crops were grouped according to similar application rates, transfer coefficients, and surrogate DFR data sources.

b Maximum application rates as stated on current endosulfan labels.

c Transfer Coefficients from Science Advisory Council on Exposure Policy 3.1[17]

d Activities are from Science Advisory Council on Exposure Policy 3.1[17] Each activity many not occur for every crop listed in group.

e The appropriate DFR surrogate data source for each crop was determined by the similarity in crop types and quality of the data.

f WP = wettable powder formulation, EC = emulsifiable concentrate formulation

g Period of time (30 days) for which the predicted residues were averaged. First day of decline period resulting in an MOE > 300 would be the first day that would not have a risk of concern. (0 days = 12 hours after application).

h Average of Predicted DFR values were obtained through study data of endosulfan residues on the foliage of melons, peach trees and grapes in CA (MRID 444031-02). DFR values were adjusted proportionately to reflect different application rates. The adjusted DFR = (study DFR X crop application rate)/study application rate.

i MOE = NOAEL (mg/kg/day) / Dermal dose (mg/kg/day). Target Intermediate-term MOE = 300.

Non-Occupational Exposures

Non-occupational exposures to endosulfan, such as from spray drift, were not included in this assessment. The Agency is developing policy on how to appropriately assess potential risks from spray drift, and after the policy is in place, the Agency will reevaluate the potential non-occupational risks from endosulfan.

Data Gaps

If the registrant is interested in refining endosulfan's restricted entry intervals, additional DFR data and/or worker exposure monitoring data may be submitted.

Occupational Post-application Summary

Short-term Exposures

For the emulsifiable concentrate formulation, the day after treatment when the calculated MOE equals or exceeds the target MOE of 100 ranges from 2 days for peppers, eggplant and tomatoes at an application rate of 1 lbs ai/acre for activities such as hand harvesting to 28 days for detasseling corn at an application rate of 1.5 lbs ai/acre. For the wettable powder formulation, the day after treatment when the calculated MOE equals or exceeds the target MOE of 100 ranges from 8 days for peppers, eggplant and tomatoes at an application rate of 1 lbs ai/acre for activities such as hand harvesting to 49 days for girdling grapes at an application rate of 1.5 lbs ai/acre. Occupational post-application risks from dermal exposure are of concern. See Table 14 for a summary.

Intermediate-term Exposures

For the emulsifiable concentrate formulation, the day after treatment when the calculated MOE equals or exceeds the target MOE of 300 ranges from 2 days for peppers, eggplant and tomatoes at an application rate of 1 lbs ai/acre for activities such as hand harvesting to 28 days for detasseling corn at an application rate of 1.5 lbs ai/acre. For the wettable powder formulation, the day after treatment when the calculated MOE equals or exceeds the target MOE of 300 ranges from 8 days for peppers, eggplant and tomatoes at an application rate of 1 lbs ai/acre for activities such as hand harvesting to 52 days for girdling grapes at an application rate of 1.5 lbs ai/acre. Occupational post-application risks from dermal exposure are of concern. See Table 14 for a summary.

Table 14. Summary of Post-application Exposure.

Crop[a]	Maximum Label Application Rate (lbs ai/acre)[d]		Transfer Coefficient[e] (cm^2/hr)	Activity[f]	Short-term Exposure		Intermediate-term Exposure	
					Day after Application When MOE 100[g]		First day of Decline Period When MOE 300[h]	
	WP[b]	EC[c]			WP[b]	EC[c]	WP[b]	EC[c]
Table Grapes / Raisins	1.5	1.5	10,000	Cane turning and tying, and girdling	49	17	**52**	17
Juice Grapes	1.5	1.5	5,000	Tying, training, hand harvesting, hand pruning, and thinning.	39	11	**42**	11
Grapes, Table and Juice	1.5	1.5	1,000	Scouting and irrigating	17	0	**20**	0
Apple, Apricot, Cherry, Nectarines, Peach, Pear, Plum, Prune, and Christmas Trees.	3	3	8,000	Thinning, staking, topping, training, and hand harvest	30	17	30	17
Ornamental Trees / Shrubs including Evergreen Trees and Non-bearing Citrus Trees.	3	3	3,000	Hand pruning and seed cone harvesting	20	6	20	6
Apple, Apricot, Cherry, Nectarines, Peach, Pear, Plum, Prune, Ornamental Trees / Shrubs including Evergreen Trees, Non-bearing Citrus Trees. and Christmas Trees.	3	3	1,000	Scouting and irrigating	8	0	8	0
Macadamia nuts and Pecans	NA	7.5	2,500	Hand harvesting, pruning, and thinning	NA	14	NA	**18**
			500	Scouting and irrigating	NA	0	NA	0
Hazelnut, Almonds and Walnut	2	2.5	2,500	Hand harvesting and pruning	14	2	14	**7**
			500	Scouting and irrigating	0	0	0	0
Blueberries, Kohlrabi, Broccoli, and Cabbage.	2	2	5,000	Hand harvesting, pruning, thinning, and irrigating.	24	20	24	20
Kohlrabi, Broccoli, and Cabbage.	2	2	4,000	Scouting and irrigating	22	19	22	19
Blueberries	2	2	1,000	Scouting and irrigating	12	8	12	8
Brussel Sprouts and Cauliflower	1	1	5,000	Topping, irrigating, hand harvesting, and tying.	19	15	19	15
			4,000	Scouting and irrigating	17	13	17	13
Corn	1.5	1.5	17,000	Detassling	31	28	31	28
			1,000	Scouting and irrigating	10	5	10	5
Cucumber, Melons, Pumpkin, Squash, Beans, Peas, Celery, Lettuce, Spinach, and Carrots.	1	1	2,500	Hand harvesting, pruning, thinning, turning, and leaf pulling	14	9	14	9
Alfalfa, Barley , Clover, Oats, Rye, Wheat, White Potatoes, Cucumber, Melon, Pumpkin, Squash, Bean, Peas, Celery, Lettuce, and Spinach.	1	1	1,500	Scouting and irrigating	10	5	10	5
Carrots	1	1	300	Scouting and irrigating	0	0	0	0

Table 14. Summary of Post-application Exposure.

Crop[a]	Maximum Label Application Rate (lbs ai/acre)[d]		Transfer Coefficient[e] (cm^2/hr)	Activity[f]	Short-term Exposure		Intermediate-term Exposure	
					Day after Application When MOE 100[g]		First day of Decline Period When MOE 300[h]	
	WP[b]	EC[c]			WP[b]	EC[c]	WP[b]	EC[c]
Pepper, Eggplant, and Tomato	1	1	1,000	Hand harvesting, staking, tying, pruning, thinning, and training.	8	2	8	2
			700	Scouting and irrigating	5	0	5	0
Pineapple	2	2	1000	Hand harvesting	12	8	12	8
			500	Scouting and irrigating	7	2	7	2
Strawberry	2	2.5	1,500	Hand harvesting, pinching, pruning, and training.	15	13	15	13
			400	Scouting and irrigating	6	2	6	2
Cotton, Collard Greens, Kale, Mustard Greens, Sweet Potato, Radish, Rutabaga, and Turnip.	2	2	2500	Hand harvesting, pruning, and thinning.	18	15	18	15
Cotton, Collard Greens, Kale, Mustard Greens and Sweet Potato.	2	2	1,500	Scouting and irrigating	15	11	15	11
Radish, Rutabaga, and Turnip.	2	2	300	Scouting and irrigating	4	0	4	0
Tobacco	1.5	3	2,000	Hand harvesting, pruning, striping, thinning, topping, and hand weeding	15	16	15	16
			1,300	Scouting and irrigating	12	13	12	13

Footnotes:

NA = Not applicable (formulation use does not exist for the crop)

a Crops were grouped according to similar application rates, transfer coefficients, and surrogate DFR data sources.

b WP = wettable powder formulation

c EC = emulsifiable concentrate formulation

d maximum application rates as stated on current endosulfan labels.

e Transfer Coefficients from Science Advisory Council on Exposure Policy 3.1[17]

f Activities are from Science Advisory Council on Exposure Policy 3.1.[17] Each activity many not occur for every crop listed in group.

g Day after application when the calculated MOE is greater than the target MOE of 100. The short-term target MOE of 100.

h First day of decline period (30 days) when average residues result in an MOE > 300, which would be the first day that would not have a risk of concern. Bolded values denote when intermediate-term DAT not resulting in a risk of concern is different than short term DAT not resulting in a risk of concern..

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